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LOT ACCEPTANCE VIA ATTRIBUTES SAMPLING (LAVAS) USER'S GUIDE

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U.S. ARMY MISSILE COMMAND
Redstone Arsenal, Alabama 35898-5000

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This user's guide describes an automation which will assist the user in the design and risk assessment of attributes sampling plans used in lot acceptance or for quality surveillance. This automation, entitled Lot Acceptance Via Attributes Sampling (LAVAS), provides for the construction of Operating Characteristic (OC) Curves and Average Sample Number (ASN) plots for single sampling, double sampling, multiple sampling, sequential sampling, and truncated sequential sampling plans. The OC Curves and ASN plots make exclusive use of the Binomial or Hypergeometric distributions for probability calculations, depending upon the conditions of application. This probabilistic approach will increase the precision of the probability of acceptance and the expected sample size to a decision since no approximation techniques, such as the Poisson and/or Normal, are used. Additionally, LAVAS provides specific design options which will expedite the design of sampling plans which are subject to risk constraints at specified quality levels.

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I. LOT ACCEPTANCE VIA ATTRIBUTE SAMPLING (LAVAS)

A. Acceptance Sampling Scope

A substantial portion of quality assurance deals with acceptance sampling. One facet of this ongoing effort deals specifically with attribute sampling in which a sampled unit is judged to be conforming or nonconforming, good or bad, successful or unsuccessful, hit or miss, reliable or failed, and so on. A unit's performance is classified in one of two ways. The purpose of acceptance sampling attributes is to perform a hypothesis test which will lead to a decision to accept or reject an inference concerning the ratio of the number of units possessing one attribute classification to the total number of units comprising the population. In the case of missiles and/or rockets, acceptance sampling is performed as a milestone which precedes the initial acceptance of a lot and as a means of monitoring stockpile reliability after the lot becomes government property.

It is pertinent to emphasize that acceptance sampling is not an attempt to estimate or control lot quality. Moreover, it is but one part of the decision process which ultimately leads to the acceptance or rejection of defined inferences pertaining to lot quality. The act of accepting or rejecting is subject to the possibility of being the wrong act. That is, one might accept when the correct decision should be to reject, or one might reject when the correct decision should be to accept. A comprehensive analysis of any sampling plan should include a complete assessment of the probability of making the wrong decision. Additionally, the comprehensive analysis should also assess the sampling burden imposed by the sampling plan. The classical approach to these two assessments involve the construction of two schematics, the Operating Characteristic (OC) curve and the Average Sample Number (ASN) plot. The OC curve provides a graphical representation of the relationship between the sampling plan's probability of acceptance and the appropriate quality characteristic. The ASN plot serves the purpose of graphically illustrating the relationship between the expected number of samples to a decision, to accept or reject, and the appropriate quality characteristic. These two schematics will be discussed in greater detail subsequently.

B. Types of Attribute Acceptance Sampling Plans

The simplest type of acceptance sampling plan is the single sampling plan. The mechanics are straightforward in that a random sample of size n is drawn from a lot or process. If the total number of defectives is less than or equal to the acceptance number (c1) the lot is accepted (i. e., the hypothesis that quality is at an acceptable level cannot be rejected). Single sampling plans are the simplest, conceptually, but they require a relatively large sample size when compared to other types of plans.

To reduce the expected sampling burden subject to constraints on the risks, double sampling plans are sometimes used. A double sampling plan is specified by five numbers, c1, c2, c3, n1, and n2. The mechanics of the plan involve drawing a random sample of n1 units. If c1 or less defectives are found in the sample, the lot is accepted without further sampling. If the sample contains c2 or more defectives, the lot is rejected with no further sampling done on the lot. If the total number of defectives is greater than c1 but less than c2, a second random sample of size n2 is drawn from the lot. If the cumulative number of defectives, from both samples, is less than or equal to c3, the lot is accepted. Otherwise, the lot is rejected. The economies realized in total samples required to a decision by instigating double sampling in lieu of single sampling are somewhat offset by the complexity associated with implementation. However, in the case of high unit cost, destructive testing, and relatively small lot sizes, the complexity involved with the implementation will yield significant dividends.

The minimum expected number of samples to a decision is obtained by the use of a sequential sampling plan, such as Wald's item–by–item sequential sampling plan. A detailed discussion of Wald's plan can be found in Reference 1. Let it suffice to say that a lot can be accepted or rejected after the sampling of a single unit. Some restrictions apply pertaining to the minimum sample size for both the acceptance and rejection ranges. There are several distinct disadvantages to Wald's plan which in many cases prevent it from being applied. Specifically, the administration burden of the plan is extremely high, the number of units sampled to a decision is variable for lots of equal quality, and the possibility exists that an entire lot can be sampled without a decision to accept or reject. Sequential sampling plans are often truncated to limit the maximum sample size and preclude the possibility of sampling the entire lot. When this is done, the resulting plan is no longer a theoretical sequential plan. It becomes a multiple sampling plan.

Multiple sampling plans specify drawing a random sample whose size is a design specification of the plan. If the total number of defectives observed in the sample is less than or equal to the first sampling tier's acceptance number, the lot is accepted. If the total number of defectives is greater than or equal to the first tier's rejection number, the lot is rejected. In either case, the decision is made and sampling ceases. If the number of defectives is greater than the acceptance number and less than the rejection number, another sample is drawn. It is not often the case nor is it necessary for the sample sizes to be equal. Each sampling tier's sample size, acceptance number, and rejection number are design parameters of the plan. After this subsequent sample is drawn and the cumulative number of defectives tabulated, the composite number of defectives is compared to the new tier's acceptance number and rejection number. If the cumulative number of defectives lies between the acceptance and rejection numbers, another sample is drawn and the procedure is repeated.

This repetitive procedure continues until the lot is accepted or rejected. A decision is guaranteed with a multiple sampling plan since the plan converges on the last sample. Convergence occurs when the acceptance number plus one equals the rejection number. In other words, there are no continuation numbers at the convergence sampling tier. Even though multiple sampling plans possess expected sample sizes to a decision which are numerically greater than those obtainable through sequential sampling, multiple sampling plans are more commonly used. This is probably due to the convergence feature and the somewhat reduced implementation burden.

C. Sampling Plan Evaluation

The evaluation of a sampling plan generally consists of two parts, an evaluation of the plan's effectiveness stated in terms of probability of acceptance versus the chosen quality characteristic and an evaluation of the plan's operating cost stated in terms of the expected number of units sampled to a decision versus the chosen quality characteristic. Both evaluations require consideration of the probabilistic aspects of the sampling implementation.

The probability of acceptance of a given sampling plan is a function of the plan itself and a function of the quality of the population of units from which the samples are drawn. The designer can exercise control over the specifics of the sampling plan, such as the numeric values of sample size and acceptance numbers, but no control is extended to the quality of the population. Therefore, the probability of acceptance must be examined over the entire range of values the quality characteristic can take on. This exercise is customarily accomplished by the use of a two–dimensional schematic called an operating characteristic curve, or simply OC curve. Figures 1 and 2 provide examples of OC curves commonly utilized. Figure 1 illustrates the case where the lower the numeric value of the quality characteristic, the better. Therefore, the

probability of acceptance is high for low values of the quality characteristic and is low for high values. The OC curve form shown in Figure 1 is the most frequently encountered and is appropriate when the quality characteristic is fraction defective or number of defectives per lot. Figure 2 provides an illustration of the case where the higher the numeric value of the quality characteristic, the better. This type of OC curve is frequently used when the quality characteristic is unit reliability or hit probability. Regardless of the numeric desirability of the quality characteristic, the OC curve provides a plot of the sampling plan's probability of acceptance versus the entire range over which the quality characteristic can take on values.

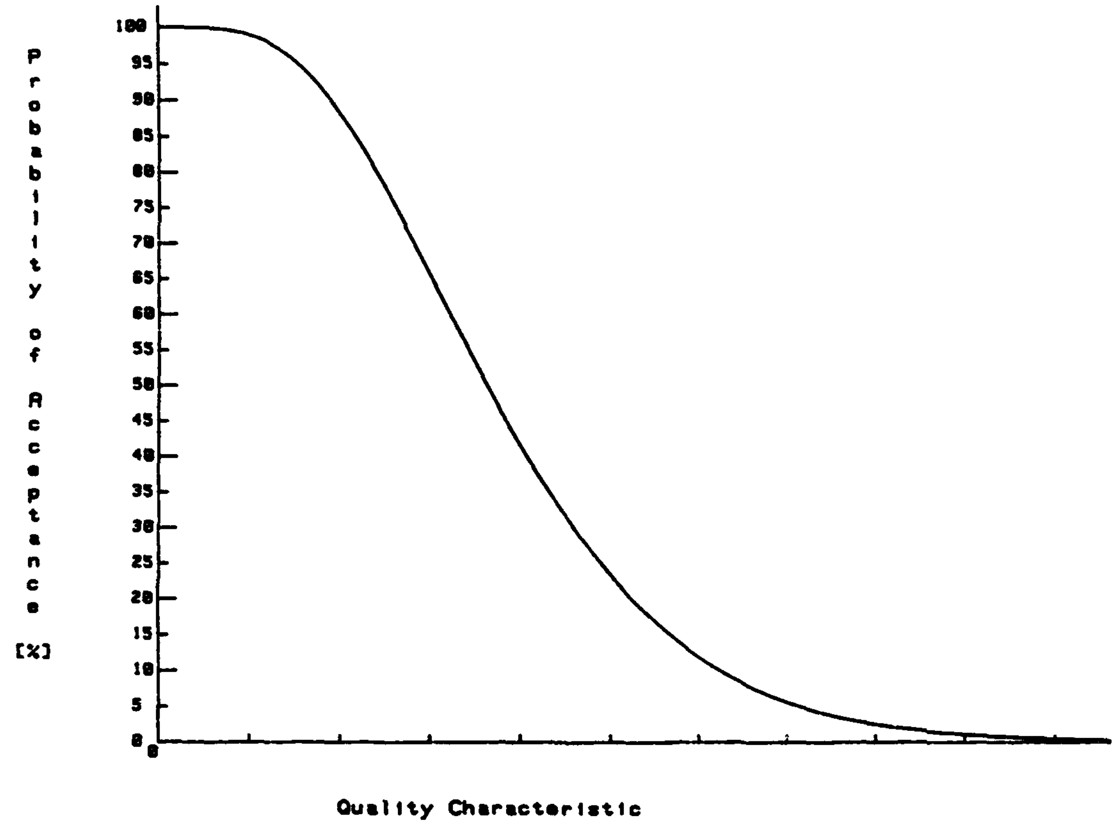

Figure 1. OC Curve for a 'Lower is Better' Quality Characteristic

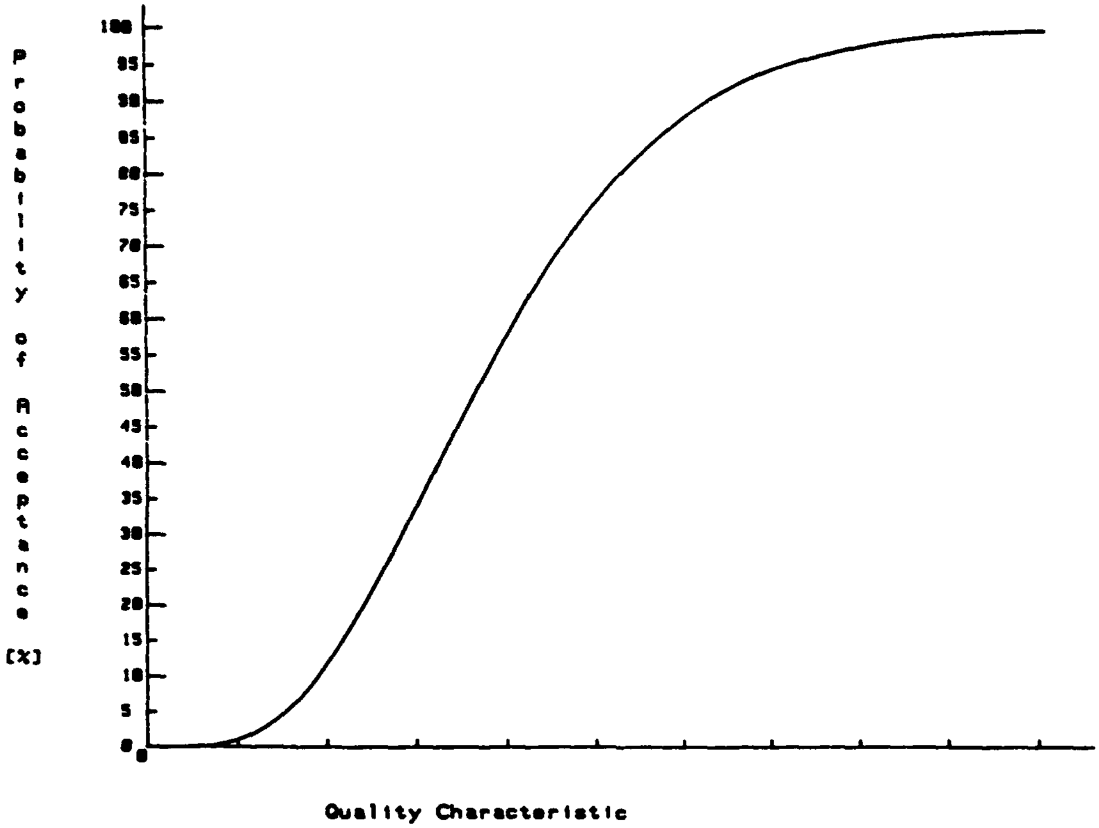

Figure 2. OC Curve for a 'Higher is Better' Quality Characteristic

In a similar fashion, the expected number of units sampled to a decision is plotted versus the full range of the quality characteristic. This type of plot is called an ASN plot. Care must be exercised in dealing with ASN plots since there are two types, those in which sampling is terminated, or curtailed, and those in which sampling is not terminated. In the case of sample termination fewer units are sampled because sampling stops as soon as an appropriate rejection number is reached. Other economies are incurred via sample termination which further reduce the expected number sampled to a decision. Consider a single sampling plan in which the sample size is 50 with an acceptance number of 2. If 48 units are inspected and none are defective, the lot would be accepted without sampling the remaining 2 units.

Figure 3 illustrates ASN plots which illustrate the contrast of instigating sample termination in this single sampling case as opposed to not instigating it. The plot shown in Figure 3 is based on a Binomial probability evaluation of the single sampling example.

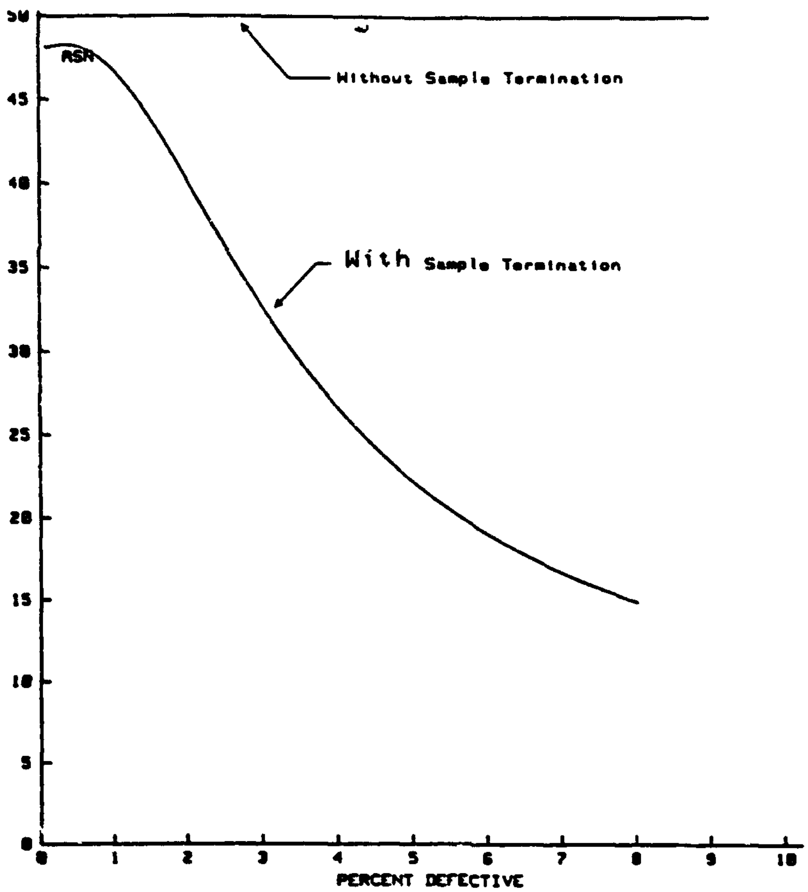

Figure 3. ASN Plot for n=50, c=2 with and without Sample Termination

D. Binomial Versus Hypergeometric Applications

In lot acceptance sampling of attribute variables, event probabilities should be calculated by either the Binomial distribution or the Hypergeometric distribution. Historically, approximation techniques involving the Poisson distribution and the Normal distribution have been used to alleviate much of the calculation burden associated with the Binomial and the Hypergeometric. With the proliferation of personal computers and their expanding computational capabilities, it is no longer necessary to resort to these approximation techniques and incur the resulting error. This increase in precision can be extremely important in applications involving the destructive testing of high dollar units such as missiles or rockets.

This increased precision is the rationale upon which the software described herein is based. All sampling plan assessments performed by this software are based strictly on one of two scenarios:

(1) Scenario #1 – A lot is submitted for sampling which possesses a finite size, N, and a finite number of defectives, M. When n units are sampled at random, the probability that exactly X defectives will be found in the sample is given by the Hypergeometric distribution as,

$$p(X, n, M, N) = \frac{(N-M)!\ M!\ n!\ (N-n)!}{(n-X)!\ (N-M-n+X)!\ X!\ (M-X)!\ N!} \quad (1)$$

Reference 1 states that this type of analysis leads to a Type A OC curve. To avoid confusion between Type A and Type B OC curves, all Type A curves provided by this source code will possess an X axis which is labeled defectives per lot. All Type B curves' X axis will be labeled percent defective.

(2) Scenario #2 – If the units of production come from a process which is in 'statistical control', producing products which possess a probability of being defective equal to p, and one desires the proportion of lots of size N that will be accepted, then the Binomial distribution should be used to calculate the probability. Specifically, when n units are randomly selected, the probability that exactly X will be defective is given by the expression,

$$p(X, n, M, N) = \frac{n!}{X!\,(n-X)!}\, p^X (1-p)^{n-X} \ . \qquad (2)$$

All probability evaluations provided by this software are based on either Equation (1) or Equation (2). The appropriate selection is a user option which can be exercised via embedded response prompts.

E. Summary

Section II provides a series of examples that, taken as a whole, constitute an exhaustive illustration of the software's applicability, input requirements, and output descriptions. The examples begin with single sampling plan design and assessment and progressively step though double sampling, multiple sampling, sequential sampling, and sequential plan truncation. In each case, the output will consist of an OC curve and an ASN plot which are free from approximation. Therefore, no spikes or points of discontinuity will be present in the schematics as is often the case when one switches approximation techniques. Section III provides a brief conclusion and extension discussion of the program's current status and envisioned enhancements. An attempt is made throughout this guide to provide a generic description of this software to divorce the use from a particular type of computer.

The appendixes contain the existing source code for the entire program. As currently programmed, the code is written in Hewlett–Packard Enhanced BASIC which is acceptable on an HP9845B desktop computer. Upon reviewing the code contained in the appendixes, the reader will quickly see the similarity between the Enhanced BASIC code and classical FORTRAN (i.e., IMAGE statements are FORMAT statements, FOR/NEXT loops are DO loops, and variable names are structured alike except that in Enhanced BASIC only the first letter of the variable name is capitalized). In short, minimal effort will be required to reprogram the source code to FORTRAN or BASIC for compatibility with various host computers. The graphical segments of the source code provided may be more challenging to convert, but the simplistic design of the logic flow is readily transferable to modern graphic packages.

II. SOFTWARE ILLUSTRATIONS

A. Lot Acceptance Via Attribute Sampling (LAVAS)

The main program, entitled Lot Acceptance Via Attribute Sampling (LAVAS), serves to dimension the program variables, to input the standard values, to display the main menu containing the primary analysis options, and to load and execute the selected option. The source code comprising LAVAS is provided as Appendix A to this report. Figure 4 provides an illustration of the main menu which contains the five analyses options. This menu is displayed at the outset of program execution and immediately precedes the first user prompt for interactive input. The remainder of this section is devoted to describing, by example, each of the five options itemized in Figure 4.

```
                 LOT ACCEPTANCE SAMPLING OPTIONS

Option Description                                    Select Code
>  Single Sampling Design And Assessment ............ 1
>  Double Sampling Design And Assessment ............ 2
>  Multiple Sampling Design And Assessment ........... 3
>  Sequential Sampling Design And Assessment ......... 4
>  Truncated Sequential Sampling or Any Convergent
   Plan Assessment (i.e., OC Curve & ASN Curve) ....... 5
>  Program Termination ............................... 6

          ENTER THE SELECT CODE OF THE DESIRED OPTION.
```

Figure 4. Main Menu

B. Single Sample Design and Assessments

This segment of the software deals exclusively with single sampling by attributes and allows for five design and/or assessment options as shown in Figure 5. The first option, entitled 'OC Curve/Risk Assessment for a Specific Plan', is the fundamental risk assessment for single sampling plans. These single sampling plan are completely described by a sample size and an acceptance number. The rejection number is assumed to be equal to the acceptance number plus one, in all cases. By entering a 1 after the prompt shown in Figure 5, the user will access an option that will provide an operating characteristic curve for any specified single sampling plan. A series of user prompts will be display at that time which are designed to accrue the input required for the assessment.

> Single Sampling Plan Option Menu <

Option Description	Select Code
>OC Curve/Risk Assessment for a Specific Plan	1
>Plan Derivation for Given AQL, LTPD, ALPHA and BETA	2
>Plan Derivation for a Single Point of Control at the Indifference Quality (Poisson Based)	3
>Plan Derivation Using J.M. Cameron's Poisson Approximation of the OC Curve	4
>Plan Derivation Via MIL–STD–105D Search for Specified AQL, LTPD, ALPHA, and BETA	5
EXIT This Segment of the Program	6

ENTER THE SELECT CODE OF THE DESIRED OPTION.

Figure 5. Single Sampling Menu

1. OC Curve/Risk Assessment for a Specific Plan

Two types of assessments are available, one based on a Binomial distribution evaluation of probabilities and one based on a Hypergeometric evaluation of probabilities. Dr. Acheson J. Duncan provides a detailed discussion of the assumptions and conditions pertaining to the applicability of each assessment type [1]. Therefore, a discussion of this topic will not be reiterated. Moreover, let it suffice to say that if a finite lot size is under investigation, the Hypergeometric should be used. Otherwise, the Binomial is appropriate.

The assessment, in this single sampling case, is primarily the OC curve. The ASN plot is a horizontal line, if sampling termination is not imposed, hence a plot option was not included. However, an average sample number plot, with sampling termination, is obtainable for sample sizes of 50 or less by exercising Option 5 of the main menu. This will be illustrated for the Binomial case, and it is also available for the Hypergeometric case. Sample termination alters the average sample plot and the OC curve from that derived for the single sampling application because sampling termination transforms the single sampling plan into a multiple sampling plan.

a. Binomial Evaluation of Single Sampling

The two assessment types, discussed above, are applied at the user's discretion and are readily chosen by the prompt responses. Specifically, immediately following the entry of a 1 for the prompt shown in Figure 5 the user will be prompted for sample size. Then a prompt will signal entry of the acceptance number. These two entries are required for either assessment type. After the acceptance number is entered, the software will display the prompt, '<u>DO YOU HAVE A FINITE LOT SIZE?</u>'. If the appropriate response is 'YES', then a Hypergeometric assessment will be performed which will be valid only for the finite lot size. If the appropriate response is 'NO', then a Binomial assessment will be performed. To illustrate the output, a sample size of 50 and an acceptance number of 1 was used to respond to the identified prompts. The response to the finite lot size prompt was 'NO'.

The curve shown in Figure 6 was obtained after entering a specification of the desired range on the percent defective axis and a desired labeling interval. These entries were prompted. Table 1 contains specific points from the OC curve. The printing of such a table is a user option. Any number of points of interest can be included in such a table. The 13 points shown are provided purely for illustration purposes.

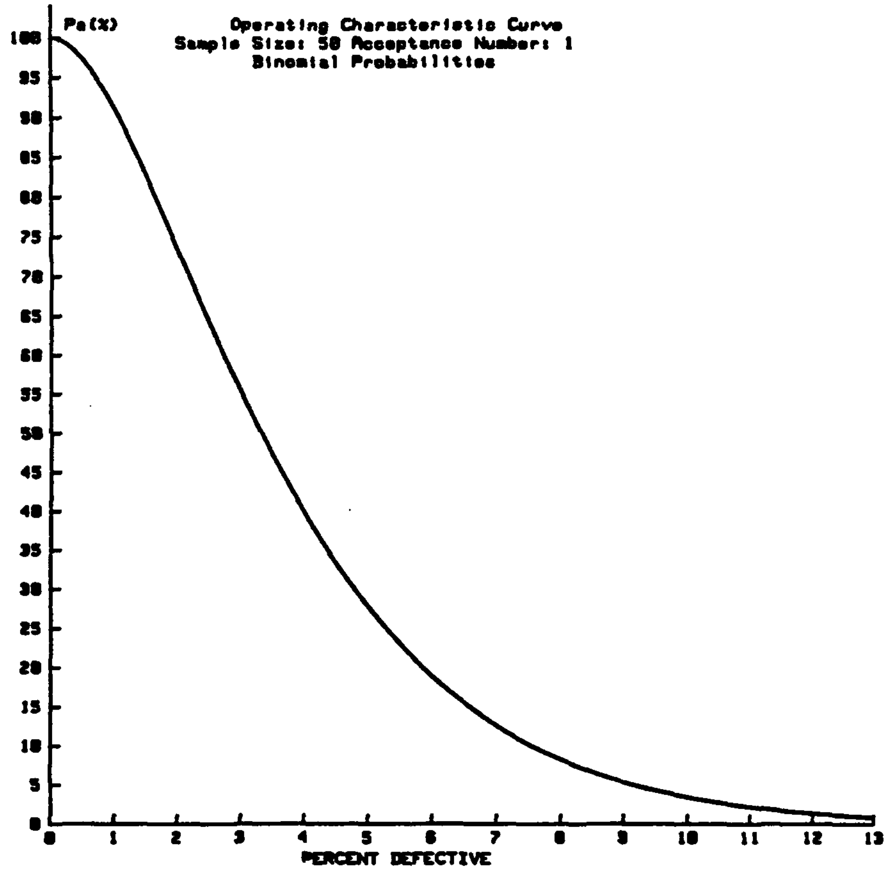

Figure 6. Binomial OC Curve for n=50, c=1

Table 1. Tabular OC Curve Points for n=50, c=1

Operating Characteristic (OC) Curve Single Sampling Plan: n = Sample and c = 1 (Binomial Distribution Probabilities)	
Percent Defective	Probability of Acceptance
.5000	97.3868
1.0000	91.0565
2.0000	73.5771
3.0000	55.5280
4.0000	40.0481
5.0000	27.9432
6.0000	19.0003
7.0000	12.6493
8.0000	8.2712
9.0000	5.3238
10.0000	3.3786
12.0000	1.3099
15.0000	.2905

Before proceeding to the Hypergeometric assessment, it is pertinent to point out that sampling termination impacts both the OC curve and the ASN plot for single sampling. To illustrate this, suppose in the previous example that sampling terminates if two defectives have accrued at any point in the sampling of 50. Further, if zero defectives have occurred after the 49th unit, the 50th unit is not sampled. Under this scenario, the single sampling plan becomes the multiple sampling plan tabularized in Table 2. By exercising Option 5 of LAVAS's menu, the output shown as Figures 7 and 8 can be obtained. A detailed discussion of the use and operation of Option 5 will be provided in a following section. This discussion of sample termination is presented here to emphasize that if the assumptions and conditions imposed by single sampling are modified in anyway, the resulting risks and expected sample size are also altered and require evaluation.

Table 2. Single Sampling with Termination

Total Number of Units Sampled	Cumulative Acceptance Number (A)	Cumulative Continuance Numbers (c)												Cumulative Rejection Number (R)
2	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
3	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
4	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
5	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
6	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
7	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
8	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
9	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
10	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
11	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
12	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
13	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
14	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
15	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
16	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
17	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
18	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
19	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
20	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
21	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
22	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
23	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
24	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
25	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
26	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
27	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
28	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
29	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
30	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
31	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
32	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
33	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
34	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
35	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
36	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
37	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
38	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
39	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
40	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
41	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
42	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
43	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
44	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
45	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
46	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
47	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
48	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
49	0	x	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
50	1	x	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2

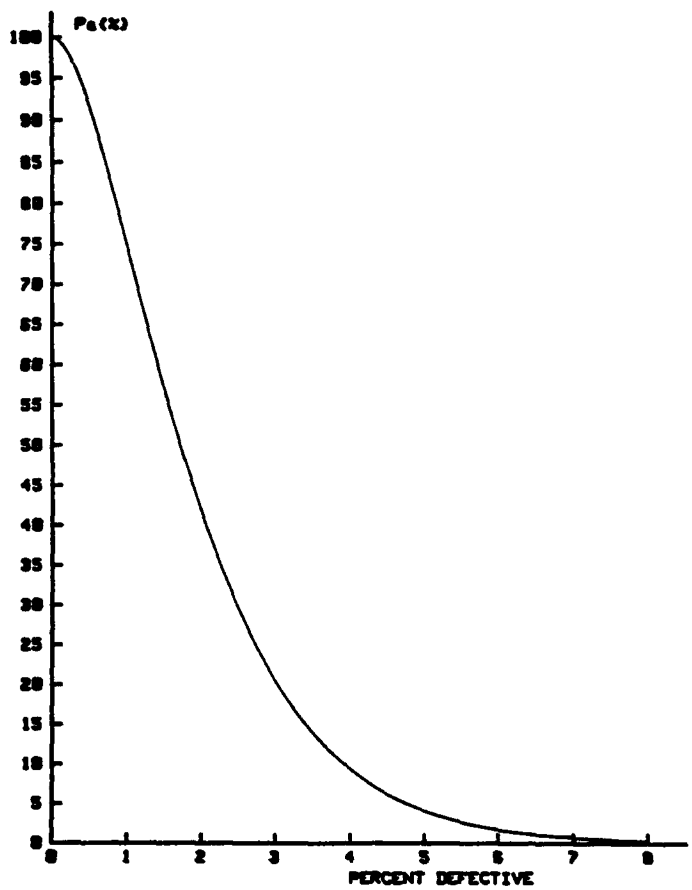

Figure 7. Sampling Termination OC Curve

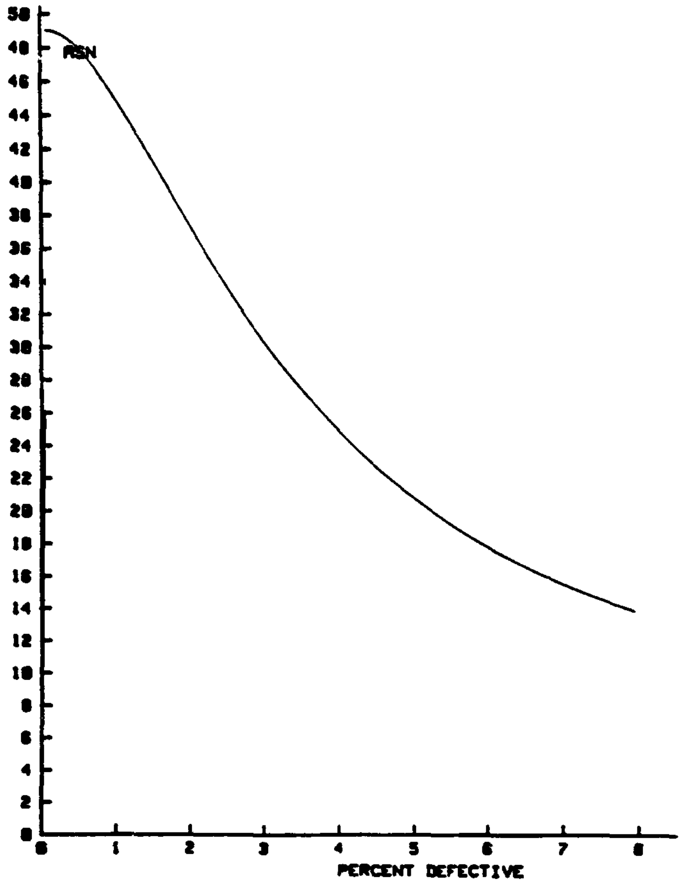

Figure 8. Sampling Termination ASN Plot

Upon comparing Figure 6 and Figure 7, it should be noted that the probability of acceptance differs for specific values of percent defective and that the shape of the curve differs for percent defective values less than or equal to 4 percent. Finally, the ASN plot, Figure 8, will continue the exhibited decay until it reaches a percent defective of 100 percent. At a percent defective of 100 percent, the plot stops at an ASN of two.

b. Hypergeometric Evaluation of Single Sampling

If the response to the prompt concerning a finite lot size is 'YES', sampling from a finite population containing M units of one classification and N–M units of another classification is assumed, where N represents the lot's size. The conditions are such that the Hypergeometric distribution is the appropriate vehicle for calculating probabilities of specific events. Heretofore, without the aid of computing equipment, analysts have resorted to approximation techniques, such as the Poisson and/or Normal, to avoid the calculation burden of the Hypergeometric. While expedient and labor saving for the analyst, the results are that approximations of risk and expected sample size have been applied to multi–million dollar tests. The cost of error resulting from approximations need not be incurred, henceforth.

To illustrate the output features, a sample size of 50, an acceptance number of 1, and a finite lot size of 144 were entered as responses to the sequential prompts. Paralleling the Binomial output, Figure 9 provides the operating characteristic curve and Table 3 provides the optional output of number of defectives per lot versus the probability of acceptance. Since the number of defectives per lot is a finite, integer, random variable, percent defective is also a finite random variable (i.e., number of defectives per lot times 100 divided by lot size). The instigation of sampling termination will alter the OC curve and the ASN plot in this application as it did in the Binomial evaluation discussed in the previous section. Option 5 of the main program's menu (Fig. 4) can be used to evaluate this scenario, as required for either the Binomial or the Hypergeometric case.

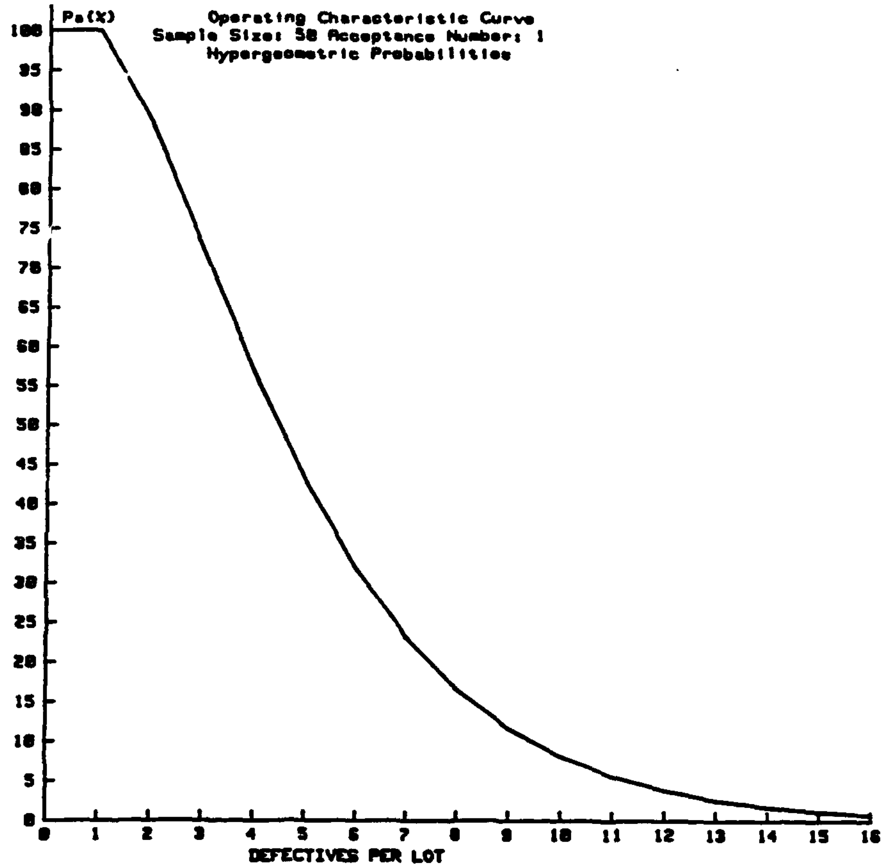

Figure 9. Hypergeometric OC Curve for n=50, c=1, and Lot Size=144

Table 3. Tabular OC Curve Points for n=50, c=1, and Lot Size=144

Operating Characteristic (OC) Curve Single Sampling Plan: n=50 and c=1 (Hypergeometric Distribution Probabilities)	
Defectives per Lot	Probability of Acceptance
0	100.0000
1	100.0000
2	88.1022
3	72.3501
4	56.7657
5	43.1107
6	31.9362
7	23.1910
8	16.5629
9	11.6614
10	8.1079
11	5.5738
12	3.7924
13	2.5557
14	1.7068
15	1.1302
20	.1279
24	.0196
30	.0009
35	.0001
36	.0000

2. Plan Derivation for Given AQL, LTPD, ALPHA, and BETA

This design option assists in the derivation of single sampling plans which pass, or nearly pass, through two points on the OC curve. The two points are (AQL, 1–ALPHA) and (LTPD, BETA). The use of this symbolism is in accordance with that most commonly encountered in statistical quality control literature where AQL is considered to be an acceptable quality level, LTPD is an unacceptable quality level, ALPHA is the producer's risk and BETA is the consumer's risk. In reality, any two desired points on the OC curve can be used equally effectively as design goals.

In its current software configuration, this option derives single sampling plans which meet design specifications on risks by strict use of the Binomial distribution to calculate event probabilities. This limitation is not considered to be restrictive since any plan derived with the Hypergeometric distribution would be valid only for the imposed lot size. The approach utilizing the Binomial distribution will enhance the precision of the design process over that achieved by using a Poisson or Poisson/Normal approximation approach.

Upon entering a 2 for the prompt illustrated in Figure 5, the user will be sequentially prompted for AQL, LTPD, ALPHA, and BETA. The inputting of these four percentages establishes the design goals of the plan. It is very improbable, due to the nature of the discrete random variables in this analysis, that a single sampling plan can be found which passes, exactly, through the two design goal points on the OC curve. Therefore, the next two prompts will request tolerance limits on the producer's risk and on the consumer's risk. The tolerance limits need not be equal to each other, and they can be zero if no tolerances exist. In an effort to address economical considerations, a prompt has been included to allow the user to place an upper limit on the sample size. If no upper limit is placed on the sample size, the software sets the limit equal to one–million. Additionally, the user has the option to limit the size of the acceptance number. After plans are analyzed for a specific acceptance number, the user will be prompted concerning the desire to increase the acceptance number by one and to continue the search.

To illustrate the use of the software, the data shown in Table 4 was used to respond to the serial prompts. Additionally, the search was limited to acceptance numbers less than or equal to five. In this application, 27 single sampling plans were found which met the design specifications and constraints. These plans are enumerated in Table 5.

Table 4. Option 2 Prompt Response Summary

Prompt Request	Response
AQL	2
LTPD	10
ALPHA	2
BETA	10
ALPHA Tolerance	1
BETA Tolerance	5
Maximum Sample Size	144

Table 5. Optional Feasible Single Sampling Plans

Optional Single Sampling Plans which Producer's Risk = 2.00 ± 1.00% Consumer's Risk = 10.00 ± 5.00% For AQL = 2.00% and LTPD = 10.00% (Binomial Probabilities)			
Sample Size	Acceptance Number	Producer's Risk	Consumer's Risk
72	4	1.48%	14.17%
73	4	1.56%	13.37%
74	4	1.65%	12.62%
75	4	1.74%	11.89%
76	4	1.83%	11.21%
77	4	1.93%	10.56%
78	4	2.03%	9.94%
79	4	2.13%	9.35%
80	4	2.24%	8.80%
81	4	2.34%	8.27%
82	4	2.46%	7.77%
83	4	2.57%	7.30%
84	4	2.69%	6.85%
85	4	2.81%	6.43%
86	4	2.94%	6.03%
91	5	1.01%	9.76%
92	5	1.06%	9.22%
93	5	1.11%	8.70%
94	5	1.17%	8.21%
95	5	1.23%	7.75%
96	5	1.29%	7.31%
97	5	1.35%	6.89%
98	5	1.41%	6.49%
99	5	1.48%	6.12%
100	5	1.55%	5.76%
101	5	1.62%	5.42%
102	5	1.69%	5.10%

If no plans are found which meet the design specifications, the user will be prompted to that effect and allowed to loosen the design tolerances and rerun the search procedure. If loosening the design tolerances is infeasible, the user may exit the design routine.

3. Plan Derivation for a Single Point of Control at the Indifference Quality (Poisson Based)

Indifference quality, sometimes called the point of control, is the fraction defective at which the probability of acceptance equals 50 percent. Conversely, the probability of rejection equals 50 percent, also. Single sample lot acceptance plans can be derived for this situation by simply calculating the sample size as

$$n = (C + .067)/p(50\%), \qquad (3)$$

where C is the acceptance number and p(50 percent) is the fraction defective at which the probability of acceptance is to be 50 percent. This relationship is credited to G.A. Cambell and is based on a Poisson distribution [2].

To access this segment of the software, the user must enter a 3 for the prompt shown in Figure 5. After doing so, the user will be prompted for the percent defective which is to possess a probability of acceptance of 50 percent. This is the only input required. The algorithm calculates sample size via Equation (3), integerizes the results, and prints the results for acceptance numbers ranging from 0 to 50. Since the resulting plans are based on a Poisson Assumption, the user should exercise Option 1 (Fig. 5), to obtain an exact risk evaluation for the use environment anticipated, be it Binomial or Hypergeometric. To illustrate the application of this option, an indifference quality of 10 percent was entered. The resulting plans are tabularized in Table 6.

Table 6. Single Sampling Plans for an Indifference Quality of 10 percent

Sample Size	Acceptance Number	Sample Size	Acceptance Number	Sample Size	Acceptance Number
7	0	177	17	347	34
17	1	187	18	357	35
27	2	197	19	367	36
37	3	207	20	377	37
47	4	217	21	387	38
57	5	227	22	397	39
67	6	237	23	407	40
77	7	247	24	417	41
87	8	257	25	427	42
97	9	267	26	437	43
107	10	277	27	447	44
117	11	287	28	457	45
127	12	297	29	467	46
137	13	307	30	477	47
147	14	317	31	487	48
157	15	327	32	497	49
167	16	337	33	507	50
Any of these plans can be evaluated by exercising Option #1					

4. Plan Derivation Using J.M. Cameron's Poisson Approximation of the OC Curve

As used within this computer program, Mr. J.M. Cameron's original intent has been somewhat modified. Reference 2 provides a detailed discussion of Mr. Cameron's approach to designing single sampling plans via Poisson approximations and two desired points from the OC curve. As applied herein, Mr. Cameron's Industrial Quality Control, Vol. 9, July 1952 table is utilized to provide the user with a single point of control at specific points on the OC curve. Namely, the user can stipulate the probability of acceptance to be 1, 5, 10, 50, 90, 95, or 99 percent for any specified percent defective. The resulting plans will approximate, via the Poisson, this single point of control for acceptance numbers ranging from 0 to 50. Exact risk assessments, via the Binomial or Hypergeometric are available through Option 1 of the menu shown in Figure 5.

Table 7 contains the output generated by entering a point of control of 2 percent and a probability of acceptance of 99 percent. Table 8 provides similar output derived from a point of control of 12 percent and a probability of acceptance of 5 percent.

Table 7. Single Sampling Plans for Point of Control Equal 2 Percent and Probability of Acceptance Equal 99 Percent

Single Sample Sampling Plans J. M. Cameron's Poisson Approximations where the Probability of Acceptance is 99.00% when the Percent Defective is 2.00%								
Sample Size	Acceptance Number	Percent Defective Specifications for which the Poisson Approximation of the Probability of Acceptance is						
		99%	95%	90%	50%	10%	5%	1%
1	0	1.00	5.10	10.50	69.30	230.30	299.60	460.50
8	1	1.86	4.44	6.65	20.98	48.63	59.30	82.98
22	2	1.98	3.72	5.01	12.15	24.19	28.62	38.21
42	3	1.96	3.25	4.15	8.74	15.91	18.46	23.92
64	4	2.00	3.08	3.80	7.30	12.49	14.30	18.13
90	5	1.98	2.90	3.50	6.30	10.31	11.68	14.56
117	6	1.99	2.81	3.33	5.70	9.00	10.12	12.45
146	7	1.99	2.73	3.19	5.25	8.06	9.01	10.96
176	8	1.99	2.67	3.09	4.93	7.38	8.20	9.89
207	9	2.00	2.62	3.01	4.67	6.86	7.59	9.07
239	10	2.00	2.58	2.94	4.46	6.45	7.10	8.43
272	11	2.00	2.55	2.88	4.29	6.10	6.69	7.90
305	12	2.00	2.52	2.83	4.15	5.83	6.37	7.48
340	13	1.99	2.49	2.79	4.02	5.58	6.08	7.10
374	14	2.00	2.47	2.75	3.92	5.38	5.85	6.80
410	15	2.00	2.45	2.72	3.82	5.19	5.63	6.52
445	16	2.00	2.43	2.69	3.75	5.05	5.46	6.30
481	17	2.00	2.42	2.67	3.67	4.91	5.30	6.09
518	18	2.00	2.40	2.64	3.60	4.78	5.15	5.90
555	19	2.00	2.39	2.62	3.54	4.67	5.02	5.74
592	20	2.00	2.38	2.60	3.49	4.57	4.91	5.59
629	21	2.00	2.37	2.58	3.44	4.48	4.81	5.46
667	22	2.00	2.36	2.56	3.40	4.40	4.71	5.34
705	23	2.00	2.35	2.55	3.36	4.32	4.62	5.23
743	24	2.00	2.34	2.54	3.32	4.25	4.54	5.12
782	25	2.00	2.33	2.52	3.28	4.18	4.46	5.03
977	30	2.00	2.30	2.47	3.14	2.90	4.16	4.65
1177	35	2.00	2.27	2.43	3.03	3.73	3.94	4.37
1380	40	2.00	2.25	2.39	2.95	3.58	3.77	4.16
1586	45	2.00	2.23	2.37	2.88	3.46	3.64	3.99
1794	50	2.00	2.22	2.35	2.82	3.36	3.53	3.85
Any of these plans can be evaluated by exercising Option #1								

Table 8. Single Sampling Plans for Point of Control Equal 12 Percent and Probability of Acceptance Equal 5 Percent

Single Sample Sampling Plans J. M. Cameron's Poisson Approximations where the Probability of Acceptance is 5.00% when the Percent Defective is 12.00%								
Sample Size	Acceptance Number	Percent Defective Specifications for which the Poisson Approximation of the Probability of Acceptance is						
		99%	95%	90%	50%	10%	5%	1%
25	0	.04	.20	.42	2.77	9.21	11.98	18.42
40	1	.37	.89	1.33	4.20	9.73	11.86	16.60
53	2	.82	1.54	2.08	5.05	10.04	11.88	15.86
65	3	1.27	2.10	2.68	5.65	10.28	11.93	15.45
77	4	1.66	2.56	3.16	6.07	10.38	11.89	15.07
88	5	2.03	2.97	3.58	6.44	10.54	11.95	14.90
99	6	2.35	3.32	3.93	6.74	10.64	11.96	14.72
110	7	2.64	3.62	4.23	6.97	10.70	11.95	14.55
121	8	2.90	3.88	4.49	7.16	10.74	11.93	14.38
131	9	3.15	4.14	4.75	7.38	10.84	11.99	14.34
142	10	3.36	4.34	4.94	7.51	10.85	11.95	14.19
152	11	3.57	4.56	5.15	7.68	10.92	11.98	14.14
163	12	3.74	4.72	5.30	7.77	10.91	11.93	14.00
173	13	3.92	4.89	5.47	7.90	10.96	11.95	13.95
183	14	4.09	5.05	5.63	8.02	11.00	11.96	13.90
193	15	4.24	5.20	5.77	8.12	11.03	11.97	13.86
203	16	4.38	5.34	5.90	8.21	11.06	11.97	13.81
213	17	4.51	5.46	6.02	8.29	11.08	11.97	13.76
223	18	4.64	5.58	6.13	8.37	11.10	11.97	13.71
233	19	4.76	5.69	6.23	8.44	11.12	11.97	13.67
243	20	4.87	5.79	6.33	8.51	11.13	11.96	13.62
253	21	4.97	5.89	6.42	8.56	11.14	11.95	13.58
262	22	5.09	6.00	6.53	8.65	11.19	11.99	13.59
272	23	5.18	6.08	6.61	8.70	11.20	11.98	13.54
282	24	5.27	6.16	6.68	8.75	11.20	11.97	13.50
291	25	5.37	6.26	6.78	8.82	11.24	12.00	13.51
340	30	5.74	6.60	7.09	9.02	8.33	11.97	13.35
387	35	6.08	6.91	7.38	9.22	11.34	11.99	13.28
434	40	6.36	7.16	7.61	9.37	11.38	12.00	13.21
481	45	6.59	7.37	7.81	9.49	11.14	11.99	13.15
528	50	6.79	7.55	7.97	9.60	11.43	11.99	13.08
Any of these plans can be evaluated by exercizing Option #1								

5. Plan Derivation Via MIL–STD–105D Search for Specified AQL, LTPD, ALPHA, and BETA

The last single sampling option, (select code 5 in Fig.5), provides a risk assessment of the sampling plans contained in MIL–STD–105D against user specified risk thresholds. Specifically, all feasible combinations of acceptance numbers and sample sizes from MIL–STD–105D's Single Sample Normal Inspection, Reduced Inspection, and Tightened Inspection are considered. Each possible plan's probability of acceptance is calculated for AQL and LTPD. The associated risks are then compared to the producer's and consumer's risk thresholds. If the calculated risks simultaneously meet the specified thresholds, the plan is printed for user consideration. Otherwise, the plan is not printed, and the search continues. The software's logic flow enables the user to: (1) input two desired points from the OC curve (i. e., [AQL, 1–ALPHA] and [LTPD, BETA]); (2) input acceptable tolerances on the risks; (3) constrain the maximum sample size; and (4) choose either the Binomial or Hypergeometric as a means for calculating event probabilities.

After accruing the specified input, the examination of the possible MIL–STD–105D plans begins. If a plan meets all design constraints, it is printed. Otherwise, the search continues until all feasible single sampling plans contained in MIL–STD–105D are exhausted. To illustrate the use of this software segment, an AQL of 1 percent, an LTPD of 12 percent, a producer's risk of 5 percent, a consumer's risk of 25 percent, 5 percent tolerances on the risks, and a maximum sample size of 50 were entered in response to the sequential prompts. The results of the Binomial evaluation are summarized in Table 9. Additionally, the results of the Hypergeometric evaluation are summarized in Table 10 for a lot size of 200. Note that the risks for the same plans, in the two tables, are different. This is due to the finite lot size associated with the Hypergeometric. The risks will converge as the lot size approaches infinity.

Table 9. Binomially Feasible MIL–STD–105D Single Sampling Plans

Optional Single Sampling Plans Via MIL–STD–105D
For AQL = 1.00% and LTPD = 12.00%
That meet Producer's Risk = 5.00 ± 5.00%
And meet Consumer's Risk = 25.00 ± 5.00%
****Binomial Probabilities****
Maximum Sample Size Constraint: 50

Sample Size	Acceptance Number	Producer's Risk	Consumer's Risk
20	1	1.69%	28.91%
32	2	.40%	24.40%

A complete OC Curve for any of these plans can be obtained by exercising Option 1 of this program segment.

Table 10. Hypergeometric Feasible MIL–STD–105D Single Sampling Plans

Optional Single Sampling Plans Via MIL–STD–105D
For AQL = 1.00% and LTPD = 12.00%
That meet Producer's Risk = 5.00 ± 5.00%
That meet Consumer's Risk = 25.00 ± 5.00%
Lot size = 200
****Hypergeometric Probabilities****
Maximum Sample Size Constraint: 50

Sample Size	Acceptance Number	Producer's Risk	Consumer's Risk
20	1	.95%	27.38%
32	2	0.00%	21.96%

A complete OC Curve for any of these plans can be obtained by exercising Option 1 of this program segment.

C. Double Sampling Design and Assessment

Though conceptually easy to understand, single sampling is an expensive means of accomplishing acceptance sampling to control percent defective. A more economical means, probabilistically speaking, is available through double sampling. The potential savings are possible even when producer's risk and consumer's risk are constrained to be constant at the levels incurred with single sampling. References 1 and 2 provide comprehensive discussions of the advantages of double sampling over single sampling; therefore, the reader can refer to those texts if further information is desired.

If a 2 is entered for the prompt shown in Figure 4, the double sampling code will be loaded and executed. Shown in Figure 10 is a narrative which briefly describes the three double sampling options currently available. Option 1, accessed by a select code of 1, provides a probabilistic risk assessment of any specified double sampling plan using either the Binomial or the Hypergeometric distribution, depending upon the sampling constraints.

> Double Sampling Plan Option Menu <

Option Description	Select Code
> Double Sample Operating Characteristic Curve Construction and Risk Assessment	1
> Double Sampling Plan Derivation, Via Poisson Approximation of ALPHA = 5% and BETA = 10% for Given Specifications of AQL and LTPD	2
> Double Sampling Plan Derivation from MIL–STD–105D Acceptance/Rejection Numbers and all Stated Sample Sizes. This option provides a Binomial or Hypergeometric Assessment of Alpha and Beta for Stated AQL and LTPD values. The assessments are limited to the feasible combinations of sample size and accept reject numbers specified in MIL–STD–105D	3
> EXIT this Selected Option	4

ENTER THE SELECT CODE OF THE DESIRED OPTION.

Figure 10. Double Sampling Menu

Additionally, this option provides an ASN plot which is simply a plot of the expected number sampled to a decision to accept or reject versus the quality characteristic. The provided ASN plot is based on the assumption that no sample termination is allowed, that is two events are possible. Once a decision is made after the first sample, or the decision is made after the second sample. No decisions can be made except at these two points in testing. If sample termination is to be allowed for economic and/or logic reasons, the user can evaluate the impact of this departure, for double sampling plans with combined sample sizes less than or equal to 50, by using Option 5 of the main menu, (Fig. 4). This evaluation will take the form of an OC curve and an ASN plot which take into consideration the sample termination policy. Sampling termination basically transforms the double sampling plan into a multiple sampling plan.

Option 2 of the double sampling section provides an automation which will assist in the design of double sampling plans in which the producer's risk is 5 percent and the consumer's risk is 10 percent. The two fraction defective values, corresponding to these two risk specifications, are considered to be variable user inputs. It is pertinent to point out that the AQL must be numerically smaller than the LTPD. The design algorithm is based upon the Poisson approximation procedure as identified by the Chemical Corps Engineering Agency [6].

The final double sampling option provides an automation which searches all feasible double sampling plans contained in MIL–STD–105D for those that satisfy the user's inputted design specifications. In other words, this portion of the software combines MIL–STD–105D sample sizes with acceptance/rejection numbers for Normal Inspection, Reduced Inspection, and Tightened Inspection; calculates the producer's risk and consumer's risk for the inputted AQL and LTPD; compares these calculated risks to the user inputted target values plus or minus the tolerances, and prints the plan if the calculated risks are within the tolerance specifications. The exhaustive search includes all double sampling plans contained in MIL–STD–105D. A feasible double sampling plan is one in which the acceptance and rejection numbers are less than the corresponding sample size.

Before proceding to the illustration of these three software options, a word of caution must be given concerning double sampling plan specifications. A double sampling plan is specified by six numbers. The first of these numbers is the first sample's size and the second number is the acceptance number on the first sample. Often overlooked is the third number, the rejection number on the first sample. If the first sample's rejection number is not specified, it is customary to assume that it is equal to the rejection number on the second sample. The rejection number on the second sample must be numerically equal to the acceptance number on the second sample plus one. To avoid confusion and possible misunderstanding, the best choice is to specify all six numbers.

1. Double Sampling OC Curve Construction and Risk Assessment

Option 1 of Figure 10 is the basic assessment algorithm for double sampling in that it provides an evaluation of the probability of acceptance, OC curve, and an ASN evaluation. If selected, the user will be serially prompted for the first sample's size, the second sample's size, the first sample's acceptance number, the second sample's acceptance number, the first sample's rejection number and the second sample's rejection number. These six inputs completely specify the double sampling plan. Attention is then focused on the conditions under which the sampling will be done (i. e., from a finite lot size or from lots such that the probability of a defective is constant from trial to trial).

Following the plan specification, the user will be prompted to enter a YES or a NO concerning the existence of a finite lot size. If the response is NO, the Binomial distribution is assumed applicable for computing probabilities. Otherwise, the Hypergeometric is assumed. To illustrate the Binomial evaluation, the data shown in Table 11 was entered for the serial prompts. When the finite lot size prompt was displayed, a NO was entered. Figure 11 provides a graphical illustration of the resulting OC curve while Figure 12 displays the plot of the ASN. The ASN plot shown in Figure 12 is based upon the assumption that no sample termination is instigated. Table 12 provides an itemization of the analysis findings for user inputted percent defectives. The scope of coverage of this table is left to the user's discretion.

Table 11. Double Sampling Binomial Option Input

PROMPT	RESPONSE
First Sample's Size	12
Second Sample's Size	24
First Sample's Acceptance Number	0
Second Sample's Acceptance Number	3
First Sample's Rejection Number	3
Second Sample's Rejection Number	4

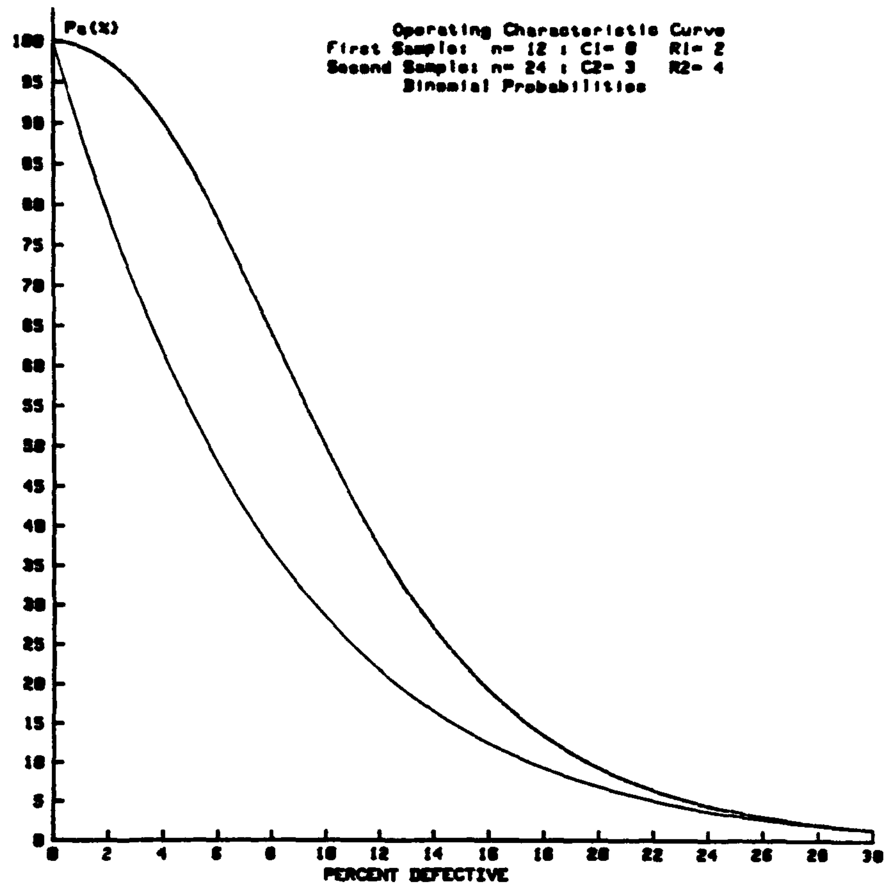

Figure 11. Double Sampling Binomial OC Curve

Table 12. OC Curve and ASN Points Versus Percent Defective For Double Sampling (Binomial)

Risk Evaluation for the Double Sampling Plan First Sample: n=12 Accept on 0, Reject on 2 Second Sample: n=24 Accept on 3, Reject on 4 (Binomial Distribution Probabilities)						
Percent Defective	First Sample Risks			Plan Risks		Average Sample Number
	Acceptance Probability	Continue Probability	Rejection Probability	Acceptance Probability	Rejection Probability	
0.0000	100.0000	0.0000	0.0000	100.0000	0.0000	12.00
1.0000	88.6385	10.7441	.6175	99.3640	.6360	14.58
2.0000	78.4717	19.2176	2.3108	97.4619	2.5381	16.61
3.0000	69.3842	25.7509	4.8649	94.2558	5.7442	18.18
4.0000	61.2710	30.6355	8.0935	89.7838	10.2162	19.35
5.0000	54.0360	34.1280	11.8360	84.2071	15.7929	20.19
6.0000	47.5920	36.4535	15.9545	77.7819	22.2181	20.75
7.0000	41.8596	37.8087	20.3317	70.8113	29.1887	21.07
8.0000	36.7666	38.3652	24.8682	63.5993	36.4007	21.21
9.0000	32.2475	38.2718	29.4806	56.4187	43.5813	21.19
10.0000	28.2430	37.6573	34.0998	49.4920	50.5080	21.04
11.0000	24.6990	36.6323	38.6687	42.9845	57.0155	20.79
12.0000	21.5671	35.2916	43.1412	37.0059	62.9941	20.47
13.0000	18.8032	33.7160	47.4808	31.6163	68.3837	20.09

Table 12. OC Curve and ASN Points Versus Percent Defective for Double Sampling (Binomial) (continued)

Risk Evaluation for the Double Sampling Plan First Sample: n=12 Accept on 0, Reject on 2 Second Sample: n=24 Accept on 3, Reject on 4 (Binomial Distribution Probabilities)						
Percent Defective	First Sample Risks			Plan Risks		Average Sample Number
	Acceptance Probability	Continue Probability	Rejection Probability	Acceptance Probability	Rejection Probability	
14.0000	16.3675	31.9737	51.6589	26.8356	73.1644	19.67
15.0000	14.2242	30.1218	55.6540	22.6531	77.3469	19.23
16.0000	12.3410	28.2081	59.4509	19.0365	80.9635	18.77
17.0000	10.6890	26.2718	63.0392	15.9402	84.0598	18.31
18.0000	9.2420	24.3448	66.4132	13.3109	86.6891	17.84
19.0000	7.9766	22.4528	69.5706	11.0932	88.9068	17.39
20.0000	6.8719	20.6158	72.5122	9.2328	90.7672	16.95
21.0000	5.9092	18.8494	75.2414	7.6785	92.3215	16.52
22.0000	5.0715	17.1650	77.7635	6.3838	93.6162	16.12
23.0000	4.3440	15.5707	80.0853	5.3076	94.6924	15.74
24.0000	3.7133	14.0716	82.2151	4.4138	95.5862	15.38
25.0000	3.1676	12.6705	84.1618	3.6719	96.3281	15.04
26.0000	2.6964	11.3685	85.9351	3.0560	96.9440	14.73
27.0000	2.2902	10.1647	87.5451	2.5442	97.4558	14.44
28.0000	1.9408	9.0573	89.0019	2.1185	97.8815	14.17
29.0000	1.6410	8.0431	90.3160	1.7641	98.2359	13.93
30.0000	1.3841	7.1184	91.4975	1.4687	98.5313	13.71
31.0000	1.1646	6.2789	92.5565	1.2221	98.7779	13.51
32.0000	.9775	5.5199	93.5026	1.0162	98.9838	13.32
33.0000	.8183	4.8364	94.3454	.8441	99.1559	13.16
34.0000	.6832	4.2232	95.0936	.7002	99.2998	13.01
35.0000	.5688	3.6753	95.7559	.5800	99.4200	12.88
36.0000	.4722	3.1876	96.3402	.4795	99.5205	12.77
37.0000	.3909	2.7550	96.8540	.3956	99.6044	12.66
38.0000	.3226	2.3729	97.3045	.3256	99.6744	12.57
39.0000	.2654	2.0365	97.6981	.2673	99.7327	12.49
40.0000	.2177	1.7414	98.0409	.2188	99.7812	12.42
45.0000	.0766	.7523	99.1711	.0767	99.9233	12.18
50.0000	.0244	.2930	99.6826	.0244	99.9756	12.07
60.0000	.0017	.0302	99.9681	.0017	99.9983	12.01
70.0000	.0001	.0015	99.9985	.0001	99.9999	12.00
75.0000	.0000	.0002	99.9998	.0000	100.0000	12.00

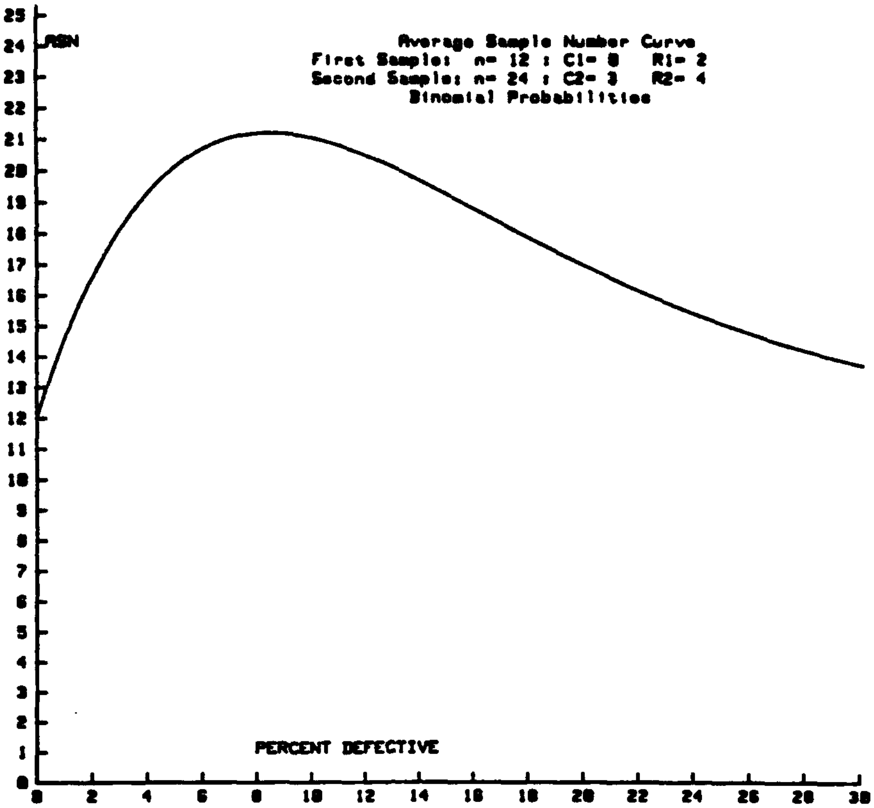

Figure 12. Double Sampling Binomial, No Sampling Termination, ASN Plot

To illustrate the Hypergeometric evaluation, a YES was entered for the finite lot size prompt. The preceding input prompts were repeated, from the Binomial illustration. Following the finite lot prompt, the user is prompted to enter the lot size. One–hundred forty–four was entered in this illustration example. Figures 13 and 14 provide schematics of the resulting OC curve and ASN plot, respectively. Table 13 contains selected points on the OC curve and the plot. Again, the number of points included in this table is the user's discretion.

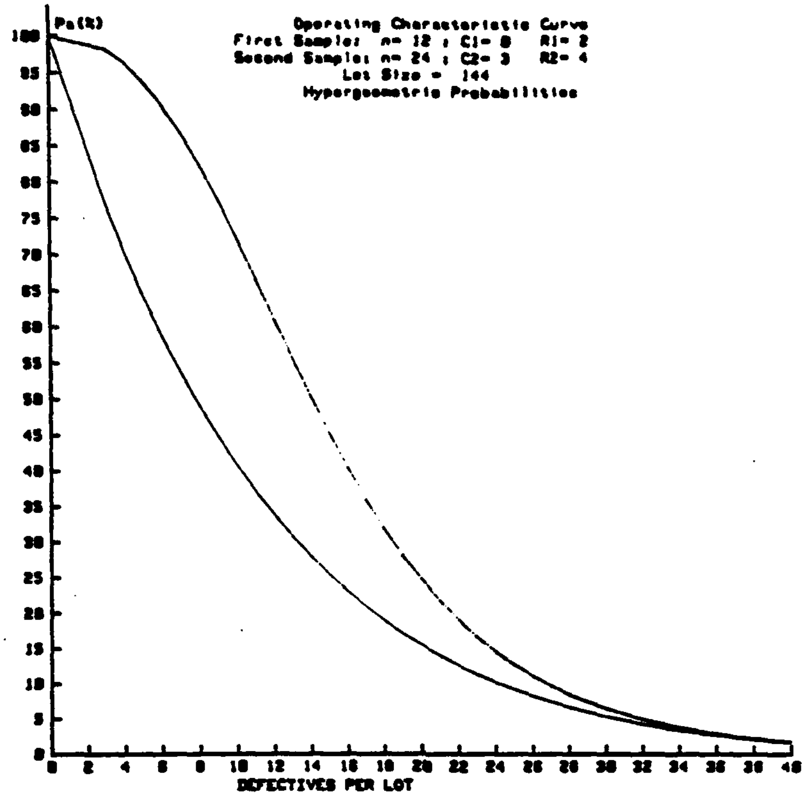

Figure 13. Double Sampling Hypergeometric OC Curve

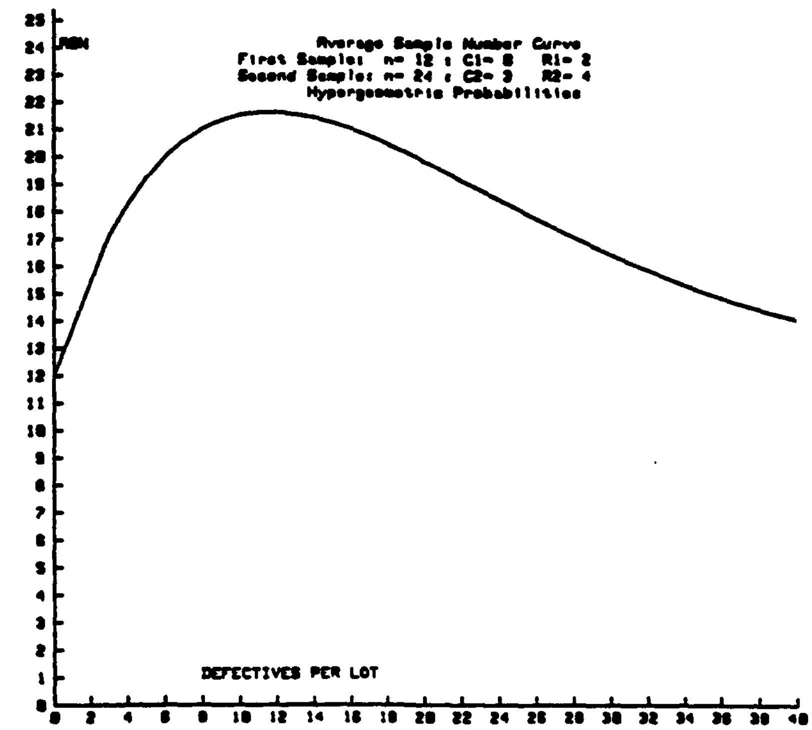

Figure 14. Double Sampling Hypergeometric, No Sampling Termination, ASN Plot

Table 13. OC Curve and ASN Points Versus Percent Defective for Double Sampling (Hypergeometric)

Risk Evaluation for the Double Sampling Plan First Sample: n=12 Accept on 0, Reject on 2 Second Sample: n=24 Accept on 3, Reject on 4 Lot Size = 144 (Hypergeometric Distribution Probabilities)						
Defective Per Lot	First Sample Risks			Plan Risks		Average Sample Number
	Acceptance Probability	Continue Probability	Rejection Probability	Acceptance Probability	Rejection Probability	
0	100.0000	0.0000	0.0000	100.0000	0.0000	12.00
1	91.6667	8.3333	-.0000	100.0000	-.0000	14.00
2	83.9744	15.3846	.6410	99.3590	.6410	15.69
3	76.8779	21.2893	1.8328	98.1672	1.8328	17.11
4	70.3351	26.1712	3.4937	96.3650	3.6350	18.28
5	64.3064	30.1436	5.5500	93.8782	6.1218	19.23
6	58.7548	33.3098	7.9354	90.6770	9.3230	19.99
8	48.9468	37.5911	13.4621	82.3030	17.6970	21.02
10	40.6610	39.6693	19.6697	72.0200	27.9800	21.52
12	33.6796	40.0815	26.2389	60.9395	39.0605	21.62
14	27.8131	39.2656	32.9213	50.0868	49.9132	21.42
16	22.8973	37.5751	39.5276	40.1896	59.8104	21.02
18	18.7900	35.2925	45.9175	31.6419	68.3581	20.47
20	15.3684	32.6409	51.9906	24.5619	75.4381	19.83
24	10.1746	26.8834	62.9420	14.4320	85.5680	18.45
25	9.1571	25.4365	65.4063	12.6036	87.3964	18.10
30	5.3301	18.6296	76.0402	6.4119	93.5881	16.47
35	3.0242	12.9607	84.0151	3.3138	96.6862	15.11
40	1.6682	8.6102	89.7216	1.7349	98.2651	14.07
45	.8921	5.4741	93.6338	.9053	99.0947	13.31
50	.4609	3.3315	96.2076	.4631	99.5369	12.80
60	.1090	1.0755	98.8154	.1091	99.8909	12.26
70	.0212	.2824	99.6965	.0212	99.9788	12.07
75	.0085	.1320	99.8595	.0085	99.9915	12.03
80	.0032	.0574	99.9394	.0032	99.9968	12.01
100	.0000	.0007	99.9992	.0000	100.0000	12.00

In the discussion of single sampling, the instigation of sample termination was discussed for the Binomial case. To illustrate the effect of sample termination in the Hypergeometric case, the previous double sampling plan was modified to reflect the effect of sample termination. The resulting multiple sampling plan is shown in Table 14. Loading Option 5 of the Main Menu (Fig. 4), and entering the plan shown in Table 14, resulted in the OC curve and ASN plot shown herein as Figure 15 and Figure 16, respectively. For comparison purposes, Table 15 was printed with common defectives per lot. Note that no significant differences exist between the probabilities of acceptance for specific defectives per lot; however economies of expected sampled units are accrued. These inferences are valid only for lot sizes of 144.

Table 14. Multiple Sampling Plan Resulting from Sample Termination of Double Sampling Plan

Multiple Plan Specification													
Total Number of Units Sampled	Cumulative Acceptance Number (A)	Cumulative Continuance Numbers (c)											Cumulative Rejection Number (R)
2	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
3	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
4	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
5	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
6	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
7	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
8	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
9	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
10	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
11	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
12	0	x	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
13	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
14	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
15	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
16	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
17	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
18	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
19	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
20	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
21	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
22	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
23	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
24	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
25	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
26	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
27	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
28	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
29	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
30	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
31	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
32	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
33	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
34	1	x	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
35	2	x	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
36	3	x	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4

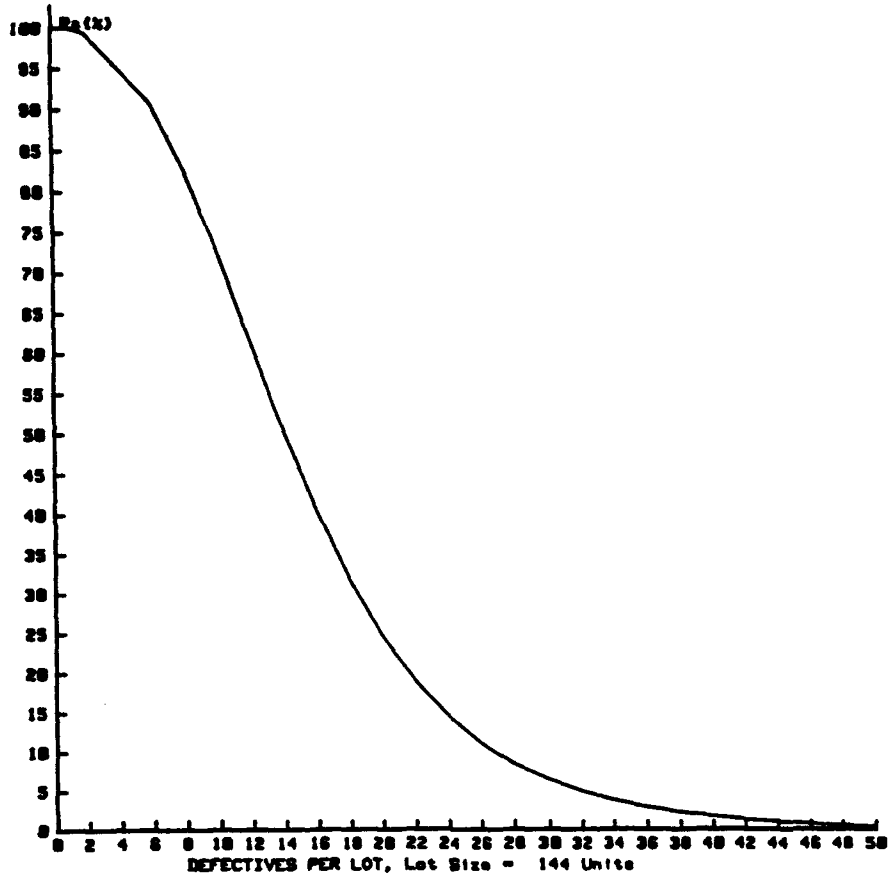

Figure 15. Multiple Sampling Via Double Sample with Sample Termination, OC Curve

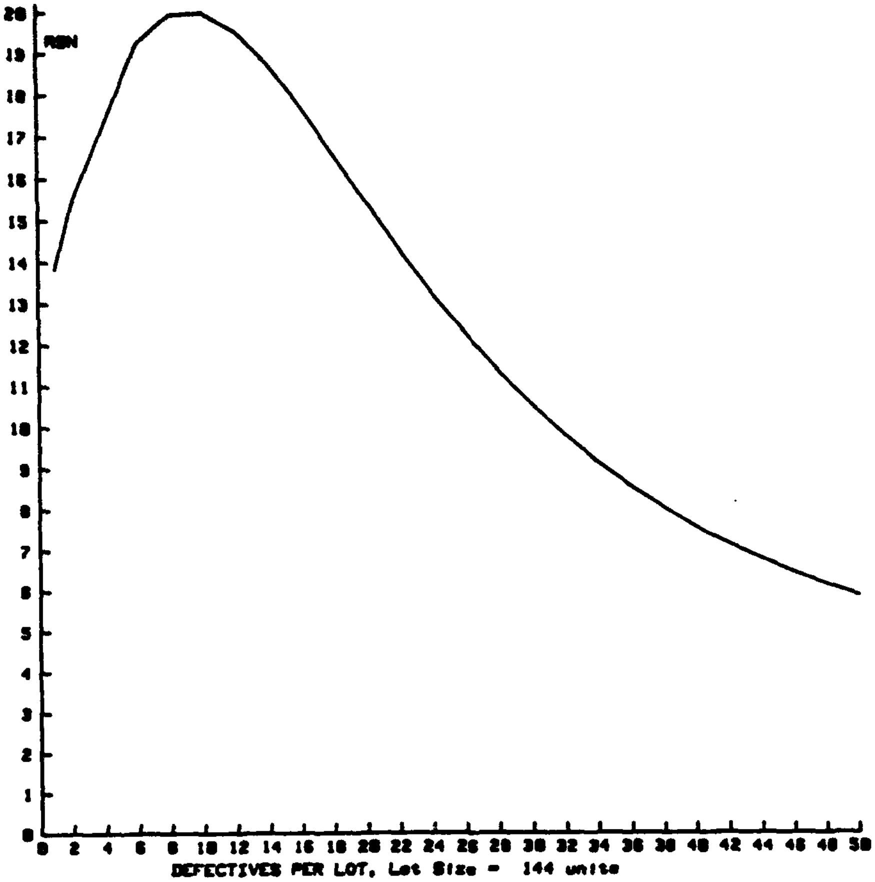

Figure 16. Multiple Sampling Via Double Sample with Sample Termination Average Sample Number Plot

Table 15. OC Curve and ASN Points from Multiple Sampling Via Double Sample with Sample Termination

Defectives Per Lot	Acceptance Probability	Sample Number
1	100.00%	13.8
3	98.17%	16.7
4	96.36%	17.8
6	90.68%	19.2
9	77.33%	20.0
10	72.02%	20.0
12	60.94%	19.5
16	40.19%	17.7
20	24.56%	15.4
24	14.43%	13.2
25	12.60%	12.7
30	6.41%	10.5
35	3.31%	8.8
40	1.73%	7.5
45	.91%	6.6
50	.46%	5.8
60	.11%	4.8
70	.02%	4.1

2. Double Sampling Plan Derivation Via Poisson Approximation of ALPHA=5 Percent and BETA=10 Percent for given Specifications of AQL and LTPD

This option provides the capability to derive double sampling plans for specified values of AQL and LTPD in which the ALPHA is 5 percent and BETA is 10 percent. Additionally, two types of double sampling plans are considered, those in which the first sample is equal in size to the second sample, and those in which the second sample is twice the first sample's size. The design algorithm is based on a Poisson approximation technique, as identified by the Chemical Corps Engineering Agency, [6].

The procedure for using this option is straightforward. A 2 is entered for the prompt shown in Figure 10 to access the software. If it is desired to have the second sample's size to be twice the first sample's size, a 1 should be entered for the prompt requesting the selection. The only other two user inputs are the numeric values of AQL and LTPD which will be entered via prompts and must be stated as percents. To obtain an output for illustration, an AQL of 2 percent and an LTPD of 8 percent were entered. Table 16 provides a copy of the resulting output. In this case, 32 double sampling plans are itemized which approximate the design specifications. Plan number 13 is very close to the desired risk values. To implement the plan, one would draw a sample of 49 units. If no defectives are found in these units, the lot is accepted with no further sampling. If six defectives are found, the lot is rejected with no further sampling. Otherwise, a second sample, consisting of 98 units must be drawn. If the cumulative number of defectives, from both samples, is less than six, the lot is accepted. If this cumulative number is six or more, the lot is rejected. The footnote at the bottom of the table is printed to remind the user that a Binomial and/or a Hypergeometric risk assessment is available for any plan selected from the table.

Table 16. Poisson Approximated Double Sampling Plans in which the Second Sample is Twice the First

Plan Option Number	Sampling Plan Specification				Percent Defective at which the P(Acceptance) is Approximately Equal			Average Sample Number Pa=95%
	Sample Size		Acceptance On					
	First Sample	Second Sample	First Sample	Second Sample	95%	50%	10%	
1	9	18	0	1	2.0000	9.3333	25.7778	11.46
2	30	60	0	1	.5333	2.8000	8.0000	38.19
3	16	32	0	2	2.0000	6.6875	15.1250	24.18
4	31	62	0	2	.9677	3.4516	8.0000	46.84
5	31	62	0	3	2.0000	5.8065	12.5484	38.38
6	49	98	0	3	1.2245	3.6735	8.0000	60.66
7	25	50	0	3	2.0000	5.4000	10.5600	44.28
8	34	68	0	3	1.4412	3.9706	8.0000	60.21
9	39	78	0	4	2.0000	5.0513	10.0513	53.00
10	50	100	0	4	1.5400	3.9400	8.0000	67.95
11	35	70	0	4	2.0000	4.6857	8.3714	69.48
12	37	74	0	4	1.8378	4.4324	8.0000	73.45
13	49	98	0	5	2.0000	4.4490	8.2041	73.40
14	51	102	0	5	1.8824	4.2745	8.0000	76.40
15	59	118	0	6	2.0000	4.1356	7.0678	97.11
16	53	106	0	6	2.1887	4.6038	8.0000	87.24

Table 16. Poisson Approximated Double Sampling Plans in which the Second Sample is Twice the First (continued)

Plan Option Number	Sampling Plan Specification: Sample Size		Acceptance On		Percent Defective at which the P(Acceptance) is Approximately Equal			Average Sample Number Pa=95%
	First Sample	Second Sample	First Sample	Second Sample	95%	50%	10%	
17	85	170	0	8	2.0000	3.8588	6.4353	125.46
18	69	138	0	8	2.4348	4.7536	8.0000	101.84
19	114	228	0	10	2.0000	3.6228	5.8947	158.23
20	85	170	0	10	2.6706	4.8588	8.0000	117.98
21	124	248	0	11	2.0000	3.5161	5.5000	182.03
22	86	172	0	11	2.8605	5.0698	8.0000	126.25
23	154	308	0	13	2.0000	3.3831	5.2273	214.68
24	101	202	0	13	3.0369	5.1584	8.0000	140.79
25	165	330	0	14	2.0000	3.2727	4.9152	242.88
26	102	204	0	14	3.2255	5.2941	8.0000	150.14
27	171	342	0	15	2.0000	3.1579	4.4152	322.85
28	95	190	0	15	3.5895	5.6842	8.0000	179.36
29	238	476	0	20	2.0000	2.9496	3.9286	482.90
30	117	234	0	20	4.0598	6.0000	8.0000	237.39
31	373	746	0	30	2.0000	2.7641	3.4745	831.79
32	163	326	0	30	4.5706	6.3252	8.0000	363.49
Exact risk assessments are available for any selected plan by exercising selection number 1 of the Double Sampling Menu.								

If it is desired that both sample sizes be equal, a 2 should be entered after the prompt requesting the decision. The AQL and LTPD are entered in the same manner as discussed above. Table 17 was obtained by entering an AQL of 2 percent and an LTPD of 8 percent. In this case, 34 plans are provided for the user's consideration. These plans approximate the design risk specifications and possess equal sample sizes for both samples.

Table 17. Poisson Approximated Double Sampling Plans in which the First and Second Samples are Equal

Plan Option Number	Sampling Plan Specification				Percent Defective at which the P(Acceptance) is Approximately Equal			Average Sample Number Pa=95%
	Sample Size		Acceptance On					
	First Sample	Second Sample	First Sample	Second Sample	95%	50%	10%	
1	11	11	0	1	2.0000	9.0909	22.7273	12.87
2	32	32	0	1	.6563	3.1250	8.0000	37.44
3	27	27	0	2	2.0000	6.7407	14.5185	29.19
4	50	50	0	2	1.0400	3.6400	8.0000	54.05
5	22	22	0	2	2.0000	6.4545	13.4545	29.48
6	38	38	0	2	1.1316	3.7368	8.0000	50.92
7	39	39	0	3	2.0000	5.4103	10.5385	45.59
8	52	52	0	3	1.4615	4.0577	8.0000	60.79
9	59	59	0	4	2.0000	4.9153	9.1356	65.20
10	68	68	0	4	1.7059	4.2647	8.0000	75.14
11	53	53	0	4	2.0000	4.7170	8.3396	67.52
12	56	56	0	4	1.8571	4.4643	8.0000	71.34
13	72	72	0	5	2.0000	4.4444	7.7083	84.24
14	70	70	0	5	2.0429	4.5714	8.0000	81.90
15	94	94	0	6	2.0000	4.2340	7.2128	105.00
16	85	85	0	6	2.2000	4.6824	8.0000	94.95
17	87	87	0	6	2.0000	4.0920	6.6897	108.58
18	73	73	0	6	2.3562	4.8767	8.0000	91.10
19	108	108	0	7	2.0000	3.9537	6.3981	126.68
20	87	87	0	7	2.4713	4.9080	8.0000	102.05
21	132	132	0	8	2.0000	3.8030	6.1364	148.37
22	102	102	0	8	2.5686	4.9216	8.0000	114.65
23	146	146	0	9	2.0000	3.6507	5.6575	170.38
24	104	104	0	9	2.7885	5.1250	8.0000	121.37
25	185	185	0	11	2.0000	3.4595	5.1676	215.71
26	120	120	0	11	3.0667	5.3333	8.0000	139.92
27	201	201	0	12	2.0000	3.3483	4.8607	244.22
28	123	123	0	12	3.2520	5.4715	8.0000	149.45
29	218	218	0	13	2.0000	3.2385	4.6239	277.08
30	127	127	0	13	3.4252	5.5591	8.0000	161.42
31	236	236	0	14	2.0000	3.1864	4.4280	314.12
32	131	131	0	14	3.5878	5.7405	8.0000	174.36
33	270	270	0	16	2.0000	3.1111	4.2259	392.04
34	143	143	0	16	3.7692	5.8741	8.0000	207.64
Exact risk assessments are available for any selected plan by exercising selection number 1 of the Double Sampling Menu.								

3. Double Sampling Plan Derivation from MIL–STD–105D Acceptance Rejection Numbers and All Stated Sample Sizes

This final double sampling option, illustrated in Figure 10, provides a search of the feasible double sampling contained in MIL–STD–105D for Normal Inspection, Tightened Inspection and Reduced Inspection. The search is initiated by inputting the AQL, LTPD, producer's risk, consumer's risk, producer's risk tolerance and consumer's risk tolerance. To expedite the search, a provision has been added within the source code to allow the user to specify a maximum total sample size. If no maximum is entered, one–million is assumed. Additionally, if the search is being conducted for a specific lot size (i . e., Hypergeometric evaluation), the user will be prompted for the numeric value of the finite lot size.

The search algorithm begins with the formulation of a double sampling plan from MIL–STD–105D. Any plan in which the acceptance, rejection, and sample numbers are compatible is considered to be feasible. The producer's risk and consumer's risk are calculated for the generated plan. If the risks are simultaneously within the risk tolerance limits, the plan is printed for user consideration. Otherwise, the plan is not printed. In either case, the formulation of another plan is initiated and the process is repeated. This iterative formulation, evaluation, and comparison is continued until all of the possible plans contained in MIL–STD–105D have been exhausted.

To illustrate this design option, the data shown in Table 18 was entered for the indicated prompts. Since the Binomial option has a faster processing time, no constraint on sample size was imposed. Table 19, contains the five MIL–STD–105D plans, output for this scenario, found to possess risks that are within the risk design tolerances. Similarly, the Hypergeometric evaluation was constrained to a total sample size of 100 or less units and a finite lot size of 250. The results of the MIL–STD–105D search are the two plans shown in Table 20.

Table 18. Double Sampling Prompt/Response Data

Prompt	Response
AQL	2
LTPD	8
ALPHA	5
BETA	10
ALPHA Tolerance	5
BETA Tolerance	8

Table 19. MIL-STD-105D Double Sampling Plans Meeting the Design Tolerances (Binomial Evaluation)

Binomial Probability Evaluation Optional MIL-STD-105D Sampling Plans AQL = 2% and LTPD = 8% Producer's Risk = 5 ± 5% and Consumer's Risk = 10 ± 8%														
Sample Size		Accept/Reject Criteria				Risk and Sampling Burden at Desired Specification							
		First		Second		Acceptable Quality Level				Tolerance % Defective			
1st	2nd	Acc	Rej	Acc	Rej	Pa	Pc	Alpha	ASN	Beta	Pc	Pr	ASN
50	50	1	4	4	5	95.2	24.6	4.8	62.3	13.2	34.3	86.8	67.1
80	80	2	5	6	7	95.5	19.3	4.5	95.5	5.2	18.3	94.8	94.6
80	80	3	7	8	9	99.5	7.6	.5	86.1	15.8	43.1	84.2	114.5
125	125	5	9	12	13	99.8	3.9	.2	129.9	7.5	26.4	92.5	158.0
200	200	9	14	23	24	100.0	.7	.0	201.5	6.8	22.7	93.2	245.5

Table 20. MIL-STD-105D Double Sampling Plans Meeting the Design Tolerances (Hypergeometric Evaluation)

Hypergeometric Probability Evaluation Optional MIL-STD-105D Sampling Plans AQL = 2% and LTPD = 8% Producers Risk = 5 ± 5% and Consumer's Risk = 10 ± 8% Maximum Total Sample Constraint: 120 Lot Size = 250													
Sample Size		Accept/Reject Criteria				Risk and Sampling Burden at Desired Specification							
		First		Second		Acceptable Quality Level				Tolerance % Defective			
1st	2nd	Acc	Rej	Acc	Rej	Pa	Pc	ALPHA	ASN	BETA	Pc	Pr	ASN
50	50	1	4	4	5	98.8	25.6	1.2	62.8	8.7	34.3	91.3	67.1
A complete assessment of any of these plans is obtainable by exercising Option #1 of this software segment.													

D. Multiple Sampling Plan Design and Assessment

Multiple sampling plans, in the form presented herein, are rarely utilized. Though somewhat more complex than double sampling, multiple sampling is instigated in an effort to reduce the expected number of units sampled to a decision for constant, specified risk levels. As used in this application, multiple sampling involves the repetitive drawing of an incremental sample size, usually represented by n. After each incremental sample is drawn, the total number of defectives is tabulated and compared to the progressive acceptance/rejection numbers. If the cumulative number of defectives is less than or equal to the acceptance number, the lot is accepted. If the cumulative number of defectives is greater than or equal to the rejection number, the lot is rejected. Otherwise, the next incremental sample size is drawn. The analyses associated with this segment of the software deal exclusively with plans in which this incremental sample size is constant. The procedure described above is repeated until the lot is either accepted or rejected. A decision to accept or reject is guaranteed since all of these plans converge. Convergence occurs when the acceptance number plus one equals the rejection number. References 1, 2, 6, and 7 provide extensive discussions and examples of these type of plans. Specifically, MIL-STD-105D provides tables of multiple sampling plans for Normal Inspection, Tightened Inspection, and Reduced Inspection, but these plans are not indexed as functions of acceptable quality, unacceptable quality, and risks. Reference 6 does provide plans indexed in the specified manner, but the risks are approximated by the use of the Poisson distribution.

However, when a plan is specified, precise risks can and should be evaluated with either the Binomial distribution or the Hypergeometric, depending upon the conditions under which the plan is to be implemented.

To assist the user in designing multiple sampling plans whose OC curves pass, or early pass, through two desired points, Option 3 of Figure 4 was created. If this option is exercised, the two design aids illustrated in Figure 17 will be displayed on the CRT. Option 1's software provides an algorithm based on the article entitled, 'Master Sampling Plans for Single, Duplicate, Double, and Multiple Sampling' by Enters and Hamaker [6]. These plans possess the common trait that they approximate a producer's risk of 5 percent for an inputted AQL and/or they approximate a consumer's risk of 10 percent for an inputted LTPD. The approximation is based on a Poisson distribution. Once the plans are identified, the algorithm uses the Binomial distribution to assess the actual risk levels. The option was not added to obtain a Hypergeometric assessment since it is anticipated that in the plan design phase the user is primarily concerned with generic lot sizes. If warranted, the Hypergeometric option can and should be included. This departure from the Chemical Corps Engineering Agency's procedure will provide a more accurate risk assessment.

Multiple Sampling Design Options

Option Description	Select Code
> Barnard–Enters–Hamaker's Poisson Approximation of Sample Size for Producer's Risk of Five Percent & Consumer's Risk of Ten Percent. Achieved Risks are Calculated Via the Binomial	1
> MIL–STD–105D Alternate Plans For Specified AQL, Producer's Risk, LTPD, and Consumer's Risk. Achieved risks are Calculated Via the Binomial	2

ENTER THE SELECT CODE OF THE DESIRED OPTION.

Figure 17. Multiple Sampling Plan Design Menu

To illustrate the option's use, an AQL of 2 percent and an LTPD of 12 percent were used as responses to the appropriate prompts. The Chemical Corps Engineering Agency procedure indicated a ratio of six (i.e., LTPD/AQL). This yields an incremental sample size of 12. As illustrated in Figure 18, the software prints, as output, a series of plans which are derived by a sensitivity analysis of the incremental sample size (i.e., the incremental sample size ranges from 11 to 15). This feature was included to provide a measure of the marginal relationship between the achieved risks and the incremental values of n. Upon reviewing Figure 18, it will be noted that each multiple sampling plan specification is followed by a note which states that a complete risk assessment is obtainable by exercising Option 5 of the main menu, (Fig. 4). If this feature is chosen, a complete Binomial assessment is available. Additionally, a complete Hypergeometric assessment is available if the plan is to be evaluated against a specified finite lot size. To illustrate the use of Option 5 in this application, a Binomial assessment was chosen. A Hypergeometric assessment will be illustrated later within this section.

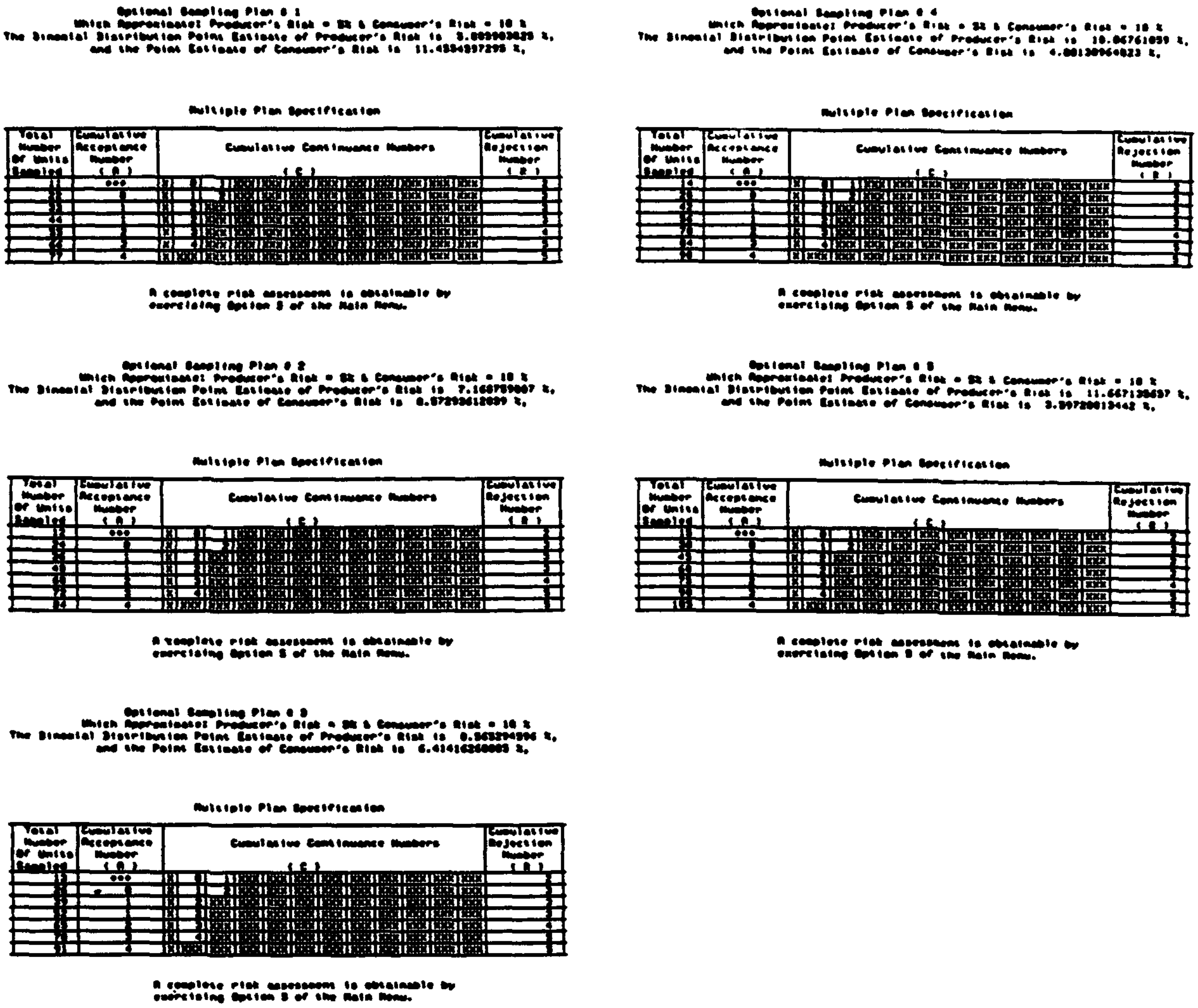

Figure 18. Multiple Sampling Plan, Option 1 Output for AQL = 2 Percent and LTPD = 12 Percent

Figure 19 provides a schematic of the resulting OC curve for Plan #1, n = 11, while Table 21 contains specific points from the curve along with the expected sample size to a decision. Shown as Figure 20 is the average sample number plot. The expected sample sizes shown in Figure 20 are based on Binomial risk evaluations and the assumption that there is no sample termination.

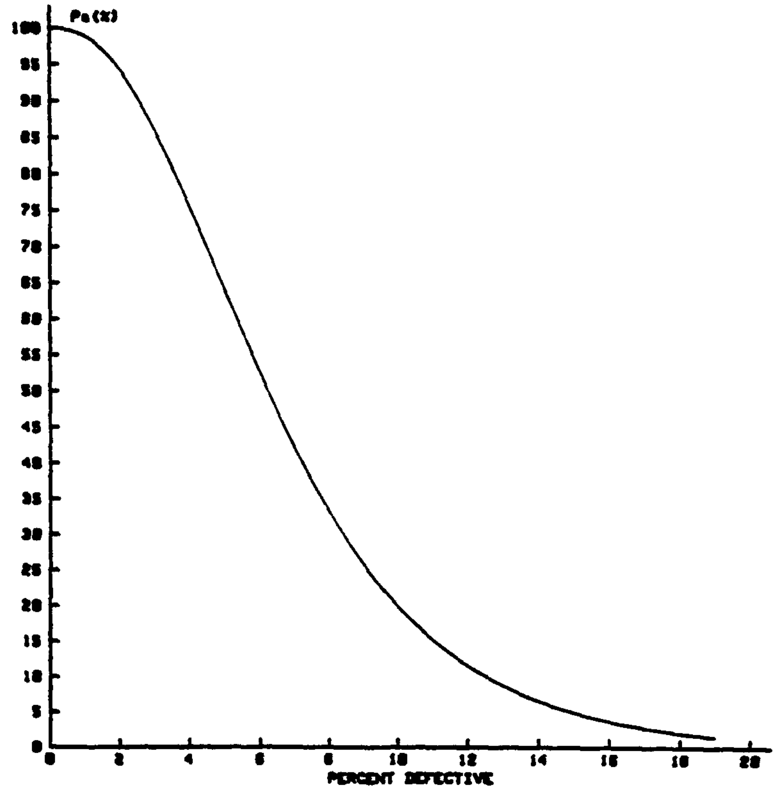

Figure 19. OC Curve for Optional Multiple Sampling Plan #1

Table 21. OC Curve/ASN Points for Optional Multiple Sampling Plan #1

Percent Defective	Acceptance Probability	Average Sample Number
1.00%	98.83%	24.7
2.00%	94.11%	27.4
3.00%	85.82%	29.4
4.00%	75.16%	30.6
5.00%	63.57%	31.0
6.00%	52.25%	30.7
7.00%	41.97%	30.0
8.00%	33.11%	28.9
9.00%	25.75%	27.6
10.00%	19.81%	26.3
11.00%	15.11%	24.9
12.00%	11.46%	23.6
13.00%	8.64%	22.4
14.00%	6.49%	21.2
15.00%	4.86%	20.1
16.00%	3.63%	19.2
17.00%	2.71%	18.3
18.00%	2.01%	17.5
19.00%	1.49%	16.7
20.00%	1.10%	16.1

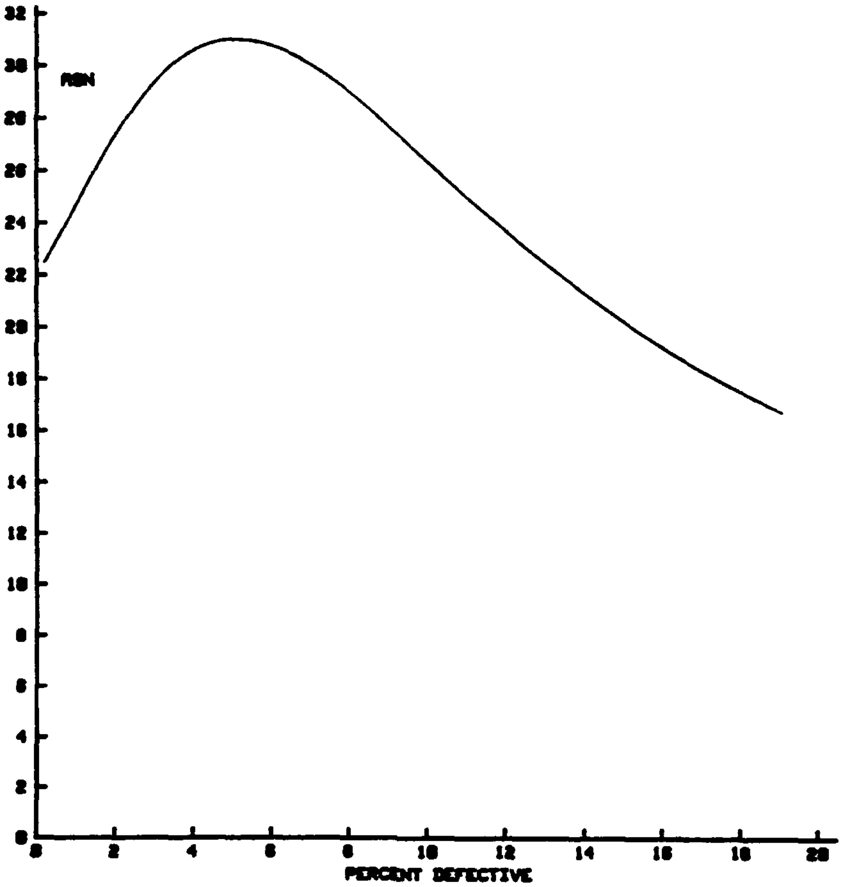

Figure 20. ASN Plot for Optional Multiple Sampling Plan #1 (without Sample Termination)

Option 2 of Figure 17 provides the user with the capability of searching the multiple sampling plan possibilities contained in MIL–STD–105D. The search is conducted to determine which plan contained therein comes closest to meeting the desired, inputted quality levels and risks. The 'closeness' criteria specified herein is stated quantitatively as

$$D = \sqrt{(\text{Prisk} - \text{Alpha})^2 + (\text{Crisk} - \text{Beta})^2} \tag{4}$$

where Prisk is the computed producer's risk for an identified plan Crisk is the identified plan's consumer's risk, Alpha is the desired producer's risk, and Beta is the desired consumer's risk. To illustrate the operation of this option, an AQL of 2 percent, an LTPD of 12 percent, a producer's risk of 5 percent and a consumer's risk of 10 percent was entered for the corresponding input prompts. The resulting output is illustrated in Figure 21. Of the multiple plans contained in MIL–STD–105D, the plan with the incremental sample size of 11 and the acceptance/rejection numbers shown in the lower right-hand corner of Figure 21 is the closest to the design criteria, where closeness is computed by Equation (4). To illustrate the complete assessment capability of Option 5 of Figure 4, the derived multiple sampling plan and a finite lot size of 500 were provided as input. The resulting Hypergeometric assessment is summarized in Figure 22, Figure 23, and Table 22. It is pertinent to point out that the results illustrated for this application are valid only for lots containing 500 units and that the ASN plot is further constrained by the assumption of no sample termination.

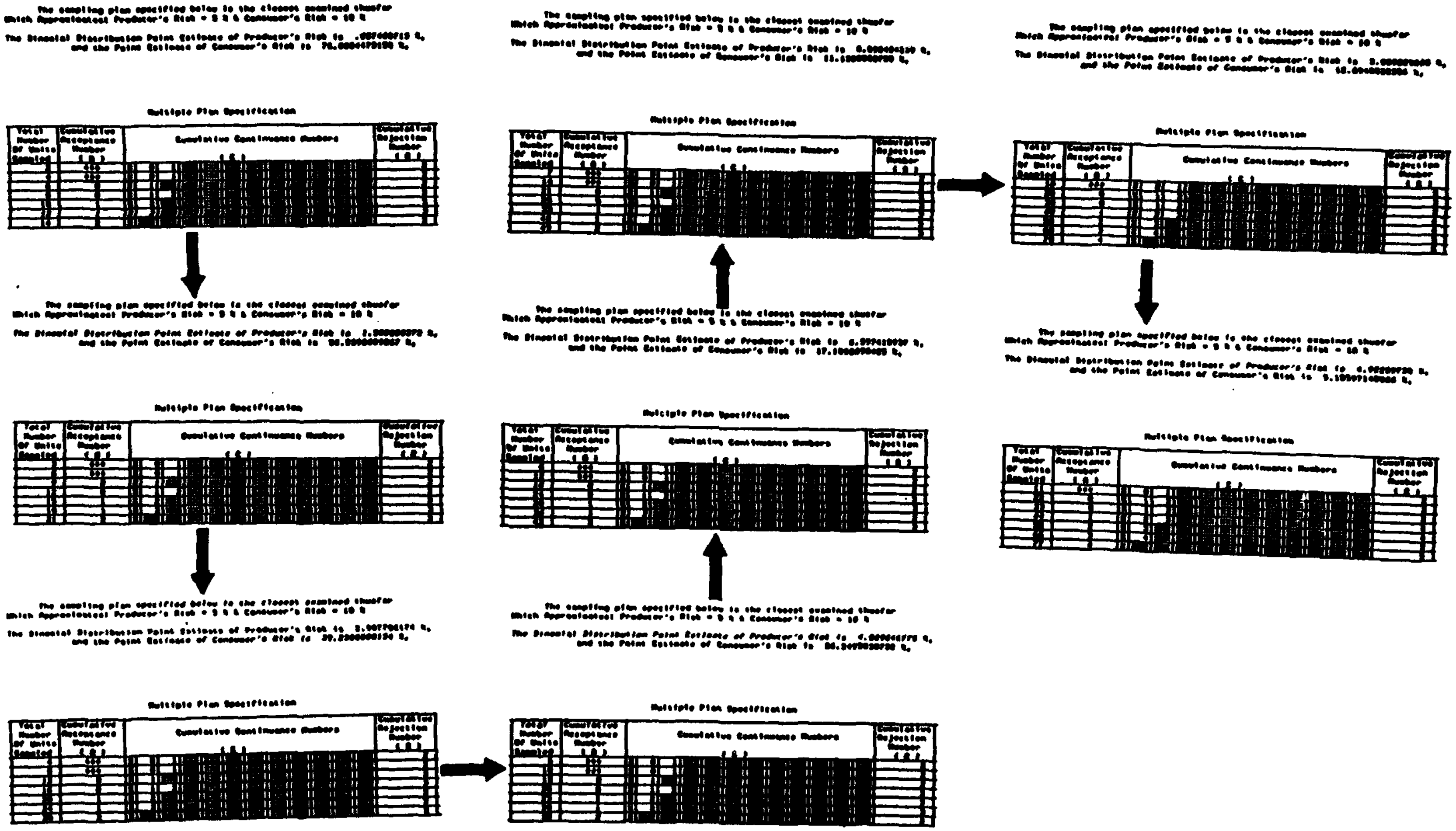

Figure 21. MIL–STD–105D Multiple Sampling Plan Research Results

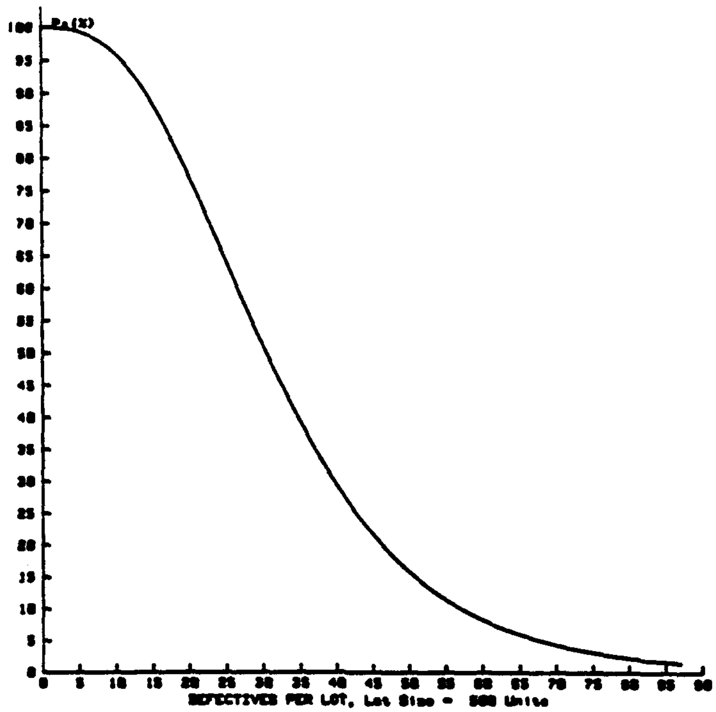

Figure 22. OC Curve for MIL–STD–105D Multiple Sampling Plan

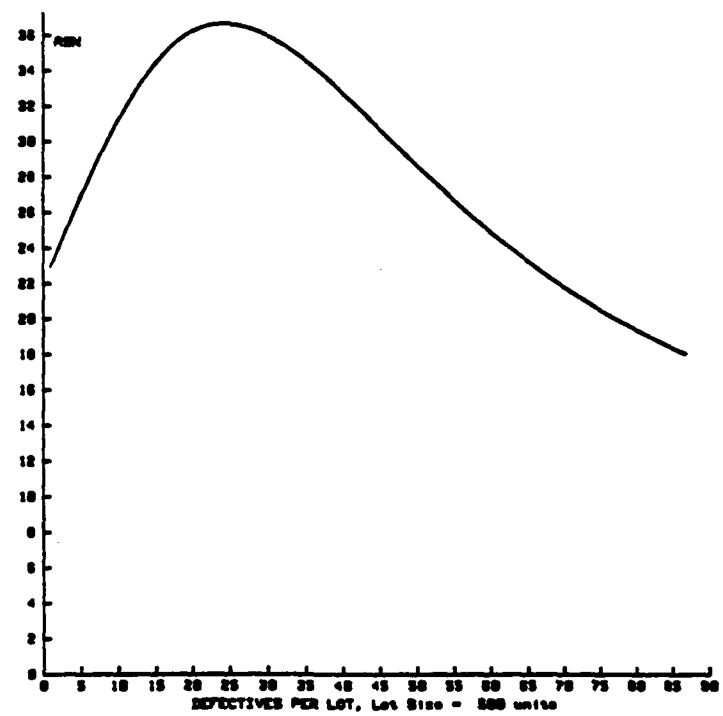

Figure 23. ASN Plot for MIL–STD–105D Multiple Sampling Plan

Table 22. OC Curve/ASN Points for MIL–STD–105D Multiple Sampling Plan

Defectives Per Lot	Acceptance Probability	Sample Number
1	100.00%	23.0
4	99.66%	25.9
10	95.89%	31.1
20	77.00%	36.2
30	50.86%	36.0
40	29.33%	32.8
50	15.71%	28.7
60	8.21%	25.0
70	4.31%	21.9
80	2.31%	19.4
90	1.26%	17.5
100	.69%	16.1

E. Sequential Sampling Design and Assessment

The final design aid provided by this automation deals with Wald's Sequential Sampling Theory. Mr. Acheson J. Duncan, [1], provides a comprehensive and thorough discussion of Wald's Sequential Sampling Plan design and assessment; therefore, Mr. Duncan's discussion will not be reiterated here. Let it suffice to say that the software contained herein, as Option 4 in Figure 4 simply automates Mr. Duncan's approach. This automation is inclusive of the operating characteristic curve and average sample number plot construction via the parametric equation approach. The software comprising this option is attached as Appendix D of this report.

Before proceeding to an example, it must be stated that the OC curve and average sample number plot, obtained via the cited parametric evaluation, are valid only if the sequential plan is adopted in its entirety. That is, no modification of any type is permitted. If this compliance is met, the austere possibility exists that an entire lot can be sampled without an acceptance or rejection decision. If destructive testing and/or high unit test cost are associated with the sampling, sequential sampling is often abandoned because of this possibility. Not withstanding this austere possibility and the relative complexity of applying the the plan, Wald's Sequential Sampling Plans do minimize the expected number of units sampled to a decision, for specified quality levels and risks. Additionally, the sequential plans often provide the basis of tailor made plans which result from truncations of the sequential sampling. If the user requires a more indepth discussion of this topic, Reference 1 should be consulted.

Upon entering a 4 for the prompt, illustrated in Figure 4 the user will be sequentially prompted for the AQL, LTPD, the producer's risk, and the consumer's risk. To illustrate the use of the sequential portion of the software, 2 percent, 12 percent, 5 percent, and 10 percent were entered for the identified prompts. The first output segment provided is an option to print the computed acceptance line and the computed rejection line. For this application, the lines were

$$\text{Acceptance Line: } X = -(1.18527087142) + .0566659067544n \qquad (5)$$

and

$$\text{Rejection Line: } X = (1.52173674436) + .0566659067544n \qquad (6)$$

where n is the chronological number of the unit sampled. The acceptance and rejection numbers are undefined for X values less than zero. Additionally, for application purposes the rejection line values are always rounded up to the higher integer while the acceptance numbers are always rounded down to the lower integer. This procedure tends to widen the continue region and does cause variation in the actual probability of acceptance and expected sample size from those expected via the aforementioned parametric evaluations. These departures are customarily assumed to be negligible.

Table 23 contains a output summary of the derived sequential sampling plan which was derived by calculating the acceptance and and rejection numbers for n values ranging from 1 to 100. It is pertinent to point out that the plan infinitely extends beyond a sample of 100. The acceptance and rejection numbers provided in Table 23 have been subjected to the rounding procedure previously discussed. Table 24 contains the results of applying the parametric equations discussed by Mr. Duncan. As such, these points, for both the probability of acceptance and the expected sample size to a decision, constitute estimates. Figures 24 and 25 provide schematics of the OC curve and the ASN plot which were derived from the points shown in Table 24. A word of caution is in order. The OC curve and the ASN plot are valid estimates only for the unbounded Wald Sequential Sampling Plan defined by the parallel lines stated as Equations (5) and (6). Any alteration of the plan in any way invalidates the referenced schematics. Alterations usually take the form of sequential plan truncation which will be subsequently addressed.

Table 23. Integerized Sequential Sampling Plan Specification

Wald's Sequential Sampling Table AQL = 2% and LTPD = 12%, Producer's Risk = 5% Consumer's Risk = 10%,											
Number of Units Sampled	If Total Defective		Number of Units Sampled	If Total Defective		Number of Units Sampled	If Total Defective		Number of Units Sampled	If Total Defective	
	Acpt	Rejt		Acpt	Rejt		Acpt	Rejt		Acpt	Rejt
1	***	***	26	0	3	51	1	5	76	3	6
2	***	2	27	0	4	52	1	5	77	3	6
3	***	2	28	0	4	53	1	5	78	3	6
4	***	2	29	0	4	54	1	5	79	3	6
5	***	2	30	0	4	55	1	5	80	3	7
6	***	2	31	0	4	56	1	5	81	3	7
7	***	2	32	0	4	57	2	5	82	3	7
8	***	2	33	0	4	58	2	5	83	3	7
9	***	3	34	0	4	59	2	5	84	3	7
10	***	3	35	0	4	60	2	5	85	3	7
11	***	3	36	0	4	61	2	5	86	3	7
12	***	3	37	0	4	62	2	6	87	3	7
13	***	3	38	0	4	63	2	6	88	3	7
14	***	3	39	1	4	64	2	6	89	3	7
15	***	3	40	1	4	65	2	6	90	3	7
16	***	3	41	1	4	66	2	6	91	3	7
17	***	3	42	1	4	67	2	6	92	4	7
18	***	3	43	1	4	68	2	6	93	4	7
19	***	3	44	1	5	69	2	6	94	4	7
20	***	3	45	1	5	70	2	6	95	4	7
21	0	3	46	1	5	71	2	6	96	4	7
22	0	3	47	1	5	72	2	6	97	4	8
23	0	3	48	1	5	73	2	6	98	4	8
24	0	3	49	1	5	74	3	6	99	4	8
25	0	3	50	1	5	75	3	6	100	4	8

Table 24. Parametric OC Curve and ASN Plot Points

Sequential Sampling AQL = 2%, Producer's Risk = 5%, LTPD = 12%, and Consumer's Risk = 10% Probability of Acceptance and Average Sample Size Versus Percent Defective					
Percent Defective	Probability of Acceptance	Average Sample Number	Percent Defective	Probability of Acceptance	Average Sample Number
.55	99.69%	23.01	5.78	53.68%	33.48
.58	99.66%	23.13	6.08	51.13%	33.17
.61	99.62%	23.26	6.30	48.58%	32.81
.65	99.57%	23.29	6.51	46.06%	32.41
.69	99.52%	23.53	6.74	43.57%	31.96
.72	99.46%	23.68	6.97	41.11%	31.47
.76	99.39%	23.84	7.20	38.71%	30.95
.81	99.32%	24.01	7.43	36.38%	30.39
.85	99.24%	24.18	7.67	34.12%	29.81
.90	99.15%	24.36	7.92	31.93%	29.20
.95	99.05%	24.56	8.17	29.83%	28.58
1.00	98.93%	24.76	8.42	27.82%	27.94
1.05	98.80%	24.97	8.67	25.90%	27.29
1.10	98.66%	25.19	8.93	24.08%	26.63
1.16	98.50%	25.42	9.20	22.35%	25.97
1.22	98.33%	25.66	9.46	20.72%	25.31
1.29	98.13%	25.91	9.73	19.19%	24.66
1.35	97.91%	26.17	10.01	17.74%	24.00
1.42	97.66%	26.45	10.28	16.39%	23.36
1.50	97.39%	26.73	10.56	15.12%	22.73
1.57	97.09%	27.02	10.84	13.95%	22.10
1.65	96.75%	27.33	11.13	12.85%	21.49
1.73	96.38%	27.64	11.42	11.83%	20.90
1.82	95.96%	27.96	11.71	10.88%	20.32
1.91	95.51%	28.29	12.00	10.00%	19.75
2.00	95.00%	28.63	12.30	9.19%	19.20
2.10	94.44%	28.98	12.59	8.44%	18.67
2.20	93.83%	29.34	12.89	7.74%	18.16
2.30	93.15%	29.70	13.19	7.10%	17.66
2.41	92.41%	30.06	13.50	6.51%	17.18
2.52	91.59%	30.43	13.80	5.97%	16.71
2.63	90.70%	30.79	14.11	5.47%	16.27
2.75	89.73%	31.15	14.42	5.01%	15.84

Table 24. Parametric OC Curve and ASN Plot Points (continued)

Percent Defective	Probability of Acceptance	Average Sample Number	Percent Defective	Probability of Acceptance	Average Sample Number
2.88	88.68%	31.51	14.73	4.59%	15.42
3.01	87.53%	31.86	15.04	4.21%	15.02
3.14	86.29%	32.20	15.35	3.85%	14.63
3.28	84.95%	32.53	15.67	3.52%	14.26
3.42	83.52%	32.84	15.98	3.23%	13.90
3.56	81.97%	33.13	16.30	2.95%	13.56
3.71	80.33%	33.40	16.62	2.70%	13.23
3.87	78.58%	33.63	16.93	2.47%	12.91
4.03	76.73%	33.84	17.25	2.26%	12.61
4.19	74.77%	34.01	17.57	2.07%	12.31
4.36	72.72%	34.14	17.89	1.89%	12.03
4.53	70.57%	34.23	18.21	1.73%	11.76
4.71	68.34%	34.27	18.53	1.58%	11.50
4.89	66.03%	34.27	18.85	1.45%	11.25
5.08	63.65%	34.21	19.17	1.32%	11.00
5.27	61.22%	34.11	19.49	1.21%	10.77
5.47	58.73%	33.95	19.81	1.10%	10.55

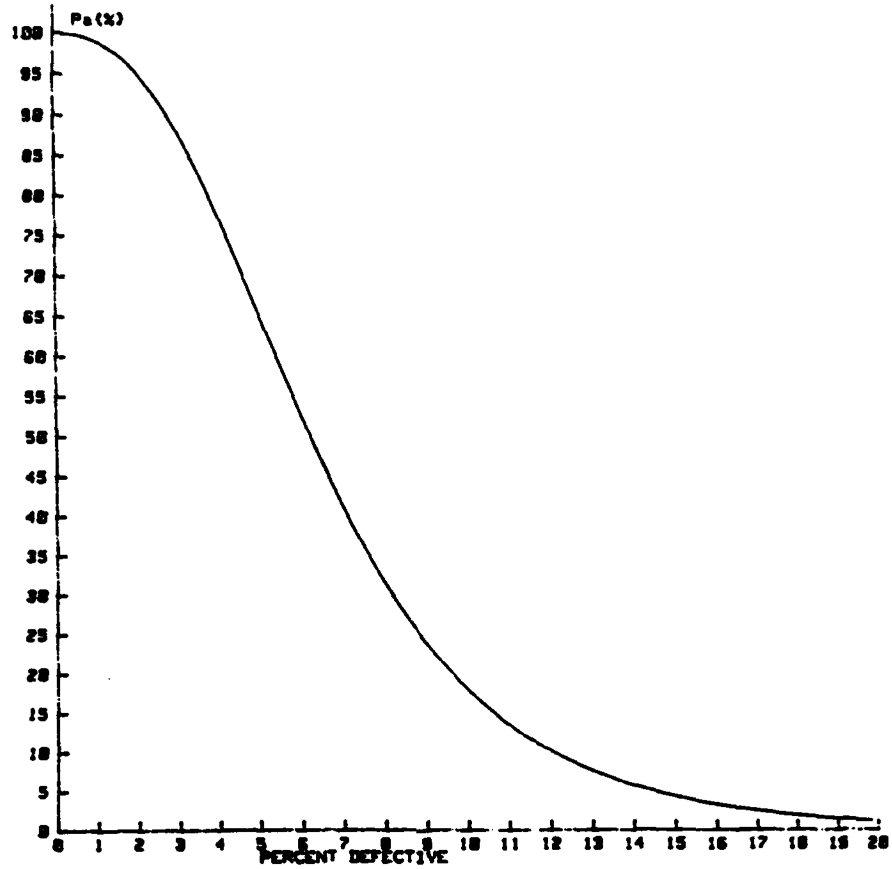

Figure 24. Parametric OC Curve for Wald's Sequential Sampling Plan

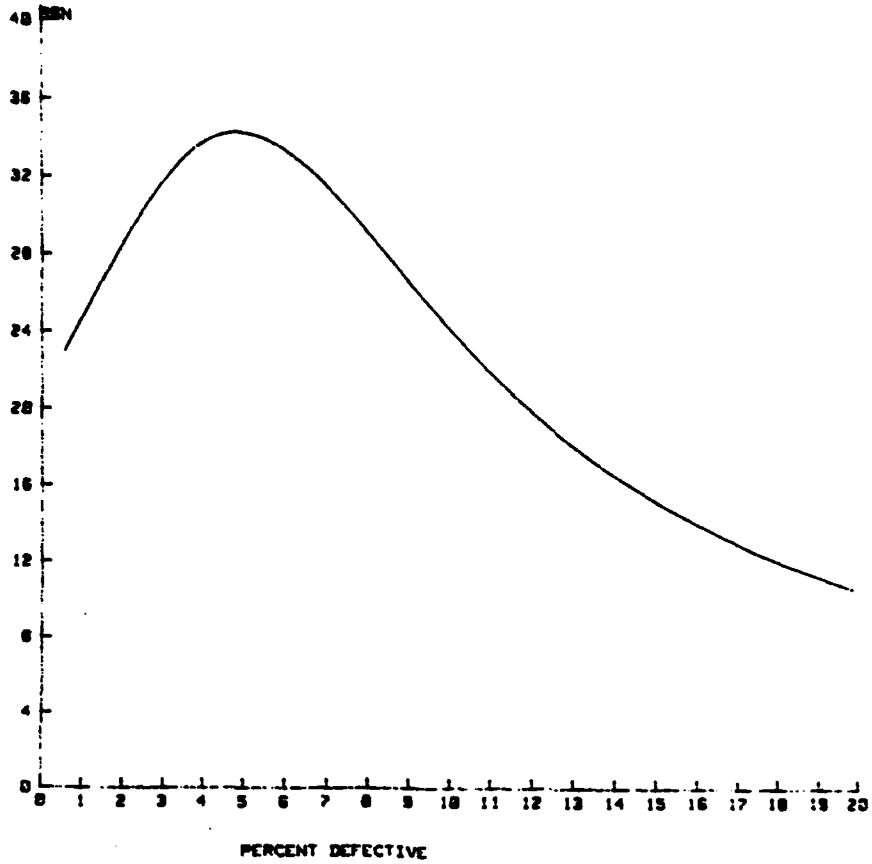

Figure 25. Parametric ASN Plot for Wald's Sequential Sampling Plan

F. Truncated Sequential Sampling or Any Convergent Plan Assessment

The greatest disadvantages associated with a sequential sampling plan are the complexity of implementing the plan and the possibility of an indefinite sample size. Consequently, many sequential sampling plans are 'made' to converge by truncating the plan. Truncating a sequential plan simply means that at some point in sampling the acceptance number plus one is made to equal the rejection number. This assures that sampling will not go beyond that point. Further modifications are often made by adjusting the numerical values of either the acceptance number or the rejection number or both. The result of this process is that the maximum sample size is guaranteed to be less than or equal to the n value associated with the point of convergence. This guarantee is offset by changes in the probability of acceptance and ASN from that assessed for the original sequential sampling plan.

As an example, consider the sequential plan shown in Table 23. Suppose the plan was altered to assure that the maximum sample size would be 50. One such alteration is shown in Table 25. The altered plan is similar to the sequential plan, but upon a close comparison it will be seen that both the acceptance and rejection numbers have been slightly altered for selected values of cumulative sample size. These alterations convert the sequential plan into a multiple sampling plan and as such possesses its own unique OC curve and ASN relationship. Option 5 (Fig. 4) can be used to expedite the assessment of the probability of acceptance and expected

sample size versus the appropriate quality characteristic, percent defective or defectives per lot. The choice of which quality characteristic is dependent on the assumption concerning lot size.

Table 25. A Sequential Sampling Plan Truncation Alternative

Total Number of Units Sampled	Cumulative Acceptance Number (A)	Cumulative Continuance Numbers (C)												Cumulative Rejection Number (R)
2	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
3	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
4	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
5	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
6	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
7	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
8	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
9	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
10	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
11	***	x	0	1	2	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	3
12	***	x	0	1	2	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	3
13	***	x	0	1	2	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	3
14	***	x	0	1	2	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	3
15	***	x	0	1	2	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	3
16	***	x	0	1	2	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	3
17	***	x	0	1	2	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	3
18	***	x	0	1	2	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	3
19	***	x	0	1	2	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	3
20	0	x	1	2	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	3
21	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
22	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
23	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
24	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
25	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
26	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
27	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
28	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
29	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
30	1	x	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
31	1	x	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
32	1	x	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
33	1	x	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
34	1	x	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
35	1	x	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
36	2	x	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
37	2	x	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
38	2	x	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
39	2	x	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4

Table 25. A Sequential Sampling Plan Truncation Alternative (continued)

Total Number of Units Sampled	Cumulative Acceptance Number (A)	Cumulative Continuance Numbers (C)												Cumulative Rejection Number (R)
40	2	x	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
41	2	x	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
42	2	x	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
43	2	x	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
44	2	x	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
45	2	x	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
46	2	x	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
47	2	x	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
48	2	x	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
49	2	x	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
50	3	x	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4

The multiple sampling plan shown in Table 25 was entered via the Option 5 prompts in Figure 4. The resulting OC curve is depicted in Figure 26, and the average sample number plot is shown in Figure 27. Table 26 contains selected points from the two referenced schematics. Also, the impacts of of altering the sequential sampling plan to assure a maximum, sample size of 50 is shown in Table 27. It is important to point out that the comparisons shown in Table 27 are valid only for the multiple sampling plan contained in Table 25. Any other alteration of the sequential sampling plan would require a similar comparison.

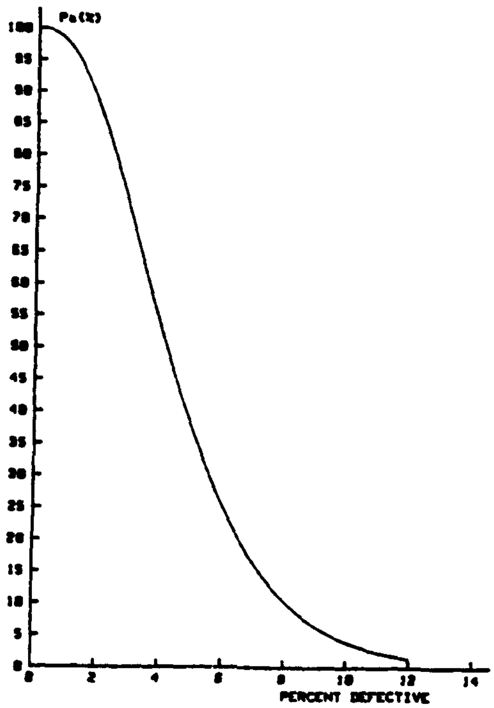

Figure 26. OC Curve for the Truncated Sequential Sampling Plan

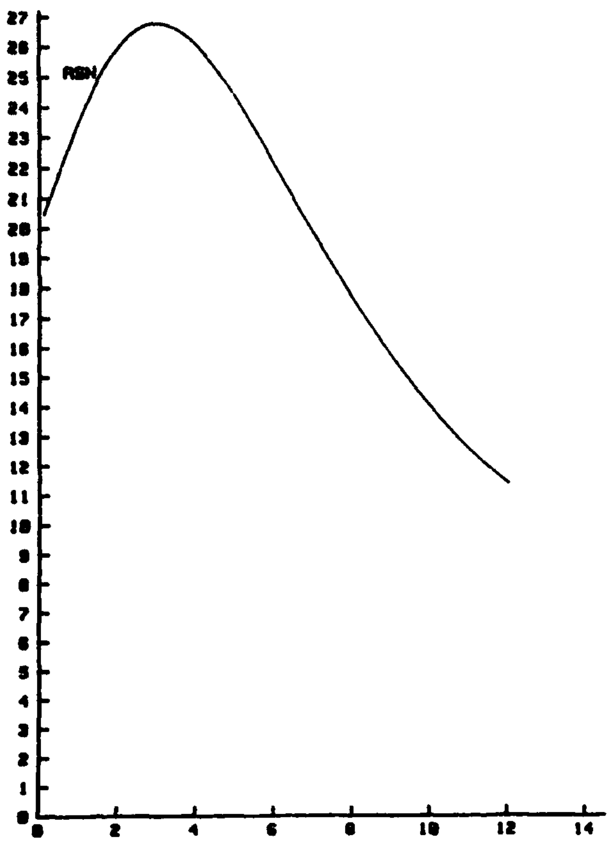

Figure 27. ASN Plot for the Truncated Sequential Sampling Plan

Table 26. Probability of Acceptance and Expected Sample Size for the Truncated Sequential Sampling Plan Alternative

Percent Defective	Acceptance Probability	Average Sample Number
1.00%	97.60%	23.5
2.00%	87.68%	26.0
4.00%	53.59%	26.0
6.00%	25.30%	22.0
8.00%	10.35%	17.6
10.00%	3.93%	14.0
12.00%	1.44%	11.3

Table 27. Sequential Versus Truncated Sequential Comparison

Plan Parameter	Wald's Sequential	Table 25's Truncated Plan
Producer's Risk	5%	12.32%
Consumer's Risk	10%	1.44%
ASN @ AQL	28.63	26.00
ASN @ LTPD	19.20	11.30

It is not the intention of this guide to discuss the relative value of one plan over another. The intent is simply to present automated quantitative techniques to enhance the user's ability to efficiently and precisely design and assess lot acceptance sampling plans. The example discussed above is based on a Binomial evaluation of event probabilities. A Hypergeometric evaluation and another aspect of Option 5 of Figure 4 are discussed below.

The manner in which samples are drawn alters the risks and expected sample sizes, if the method of sampling departs from that specified by the plan. To illustrate, suppose the plan shown in Table 25 is to be used in conjunction with a lot containing 500 units. Instead of the single unit, consecutive sampling indicated in Table 25, the sampling is constrained to be clustered as shown in Table 28. Simply stated, accept/reject decisions can occur only after a sample number has been drawn (i . e., there are thirteen points at which a lot can be accepted or rejected). This type of sampling often occurs in ripple firing or multiple launch missile/rocket firings. The sampling plan shown in Table 25 can easily be modified to accommodate the cluster sampling scenario and can he detailed as shown in Table 29.

Table 28. Cluster Sampling Constraints

Sample Number	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13
Sampling Increment	6	3	2	1	6	2	6	4	6	5	4	3	2
Cumulative Sample Size	6	9	11	12	18	20	26	30	36	41	45	48	50

Table 29. Cluster Sampling Acceptance/Rejection Criteria

Total Number of Units Sampled	Cumulative Acceptance Number (A)	Cumulative Continuance Numbers (C)												Cumulative Rejection Number (R)
6	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
9	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
11	***	x	0	1	2	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	3
12	***	x	0	1	2	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	3
18	***	x	0	1	2	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	3
20	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
26	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
30	1	x	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
36	2	x	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
41	2	x	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
45	2	x	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
48	2	x	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
50	3	x	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4

Two alterations of the assumptions under which Figure 26 and Figure 27 were constructed will cause significant departures in the actual operating characteristic curve and average sample number plot of the implemented plan. The first alteration is the fact that a finite lot size of 500 units is known which requires a Hypergeometric evaluation in lieu of a Binomial evaluation. The second alteration is that there are 49 accept/reject decision points in Table 25, and there are only 13 such points in Table 29. The effect of these two alterations can be readily assessed by Option 5 of Figure 4.

Upon entering the sample size values at which accept/reject decisions are made and the respective acceptance numbers and rejection numbers at these sample sizes, via Option 5's prompts the OC curve shown in Figure 28 is obtained. Additionally, the expected number sampled to a decision is shown in the ASN plot included as Figure 29, the effect of clustering the samples, as described above, and the application of a finite lot size of 500 on the truncated sampling plan, shown in Table 25 is summarized in Table 30.

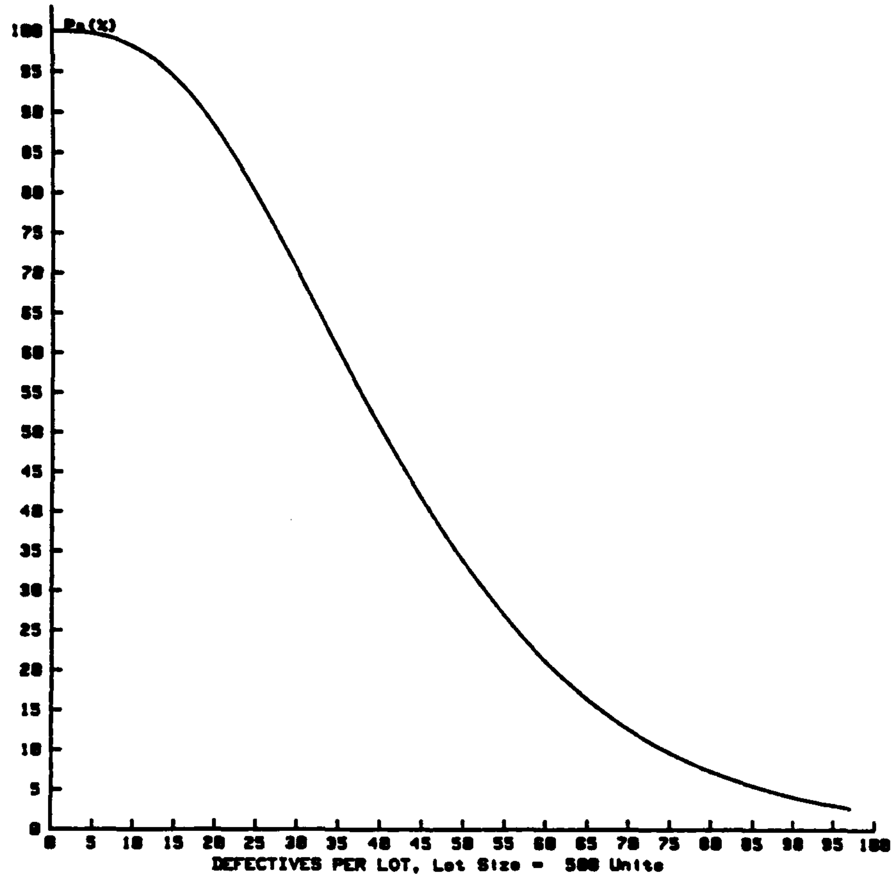

Figure 28. Cluster Sampling OC Curve

Table 30. Truncated Versus Cluster Sampling Comparison

Plan Parameter	Truncated	Clustered
Producer's Risk	12.23%	1.93%
Consumer's Risk	1.44%	21.22%
ASN @ AQL	28.63	28.30
ASN @ LTPD	19.20	23.30

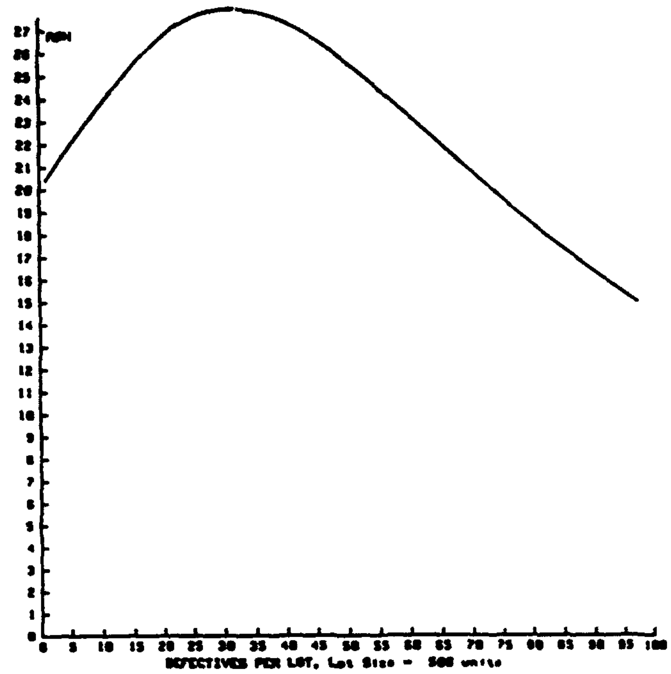

Figure 29. Cluster Sampling ASN Plot

G. Summary

The purpose of this section is to provide a series of example problems and the associated output which collectively, provide an exhaustive illustration of the scope of application of the software attached hereto as appendixes. The prime consideration, repetitively stated within this section, is that no approximations of event probabilities are made. Moreover, the event probabilities are calculated by the Hypergeometric distribution when finite lot sizes are a consideration, and they are calculated by the Binomial distribution when finite lot sizes are not a consideration.

The increased precision of risk forecasts and expected sample size expenditures to a decision is a significant advantage; however it is only one aspect of this software. Option 5 of Figure 4 is perhaps the most significant advantage in that it affords expedient risk assessments and ASN evaluations for any and all convergent sampling plans. This generic evaluator could, if desired, replace large portions of the software devoted to the evaluation of these parameters in Options 1, 2, and 3.

III. CONCLUSIONS AND EXTENSIONS

The primary technical advantage provided by the use of LAVAS is the automation of the tremendous calculation burden imposed in performing event probability evaluations using the Binomial or the Hypergeometric distributions. The burden is well recognized as being significant as evidenced by the proliferation of approximation techniques found in current literature pertaining to attribute sampling for lot acceptance. Regardless of the efficiency of a particular approximation technique, it is just that, an approximation technique which infers some degree of error. Destructive testing of modern missiles and/or rockets imposes such austere cost accruals that precision in risk assessments is vital.

Additionally, LAVAS provides risk assessments for any convergent sampling plan, in addition to the common plan types. This feature is particularly useful and expeditious when sequential sampling plans are truncated or when multiple sampling plans with variable incremental sample sizes are to be evaluated. In short, LAVAS can be effectively used to precisely construct OC curves and ASN plots for any attribute sampling plan. LAVAS also includes selected design algorithms which will aid the user in deriving attributes sampling plans which are constrained at specified risk levels. These design features also include provisions set forth in MIL–STD–105D in that risk design thresholds can be provided as input and MIL–STD–105D sampling plans, which meet the inputted risk thresholds will be specified as output. In conclusion, LAVAS can be viewed as a sampling plan design aid and an extensive, precise sampling plan risk assessor.

Future efforts to enhance the methodology automated in LAVAS are envisioned to be focused on two areas. First, faster execution is desirable. To that end, faster techniques will be researched to perform the factorial ratios required for both the Binomial and the Hypergeometric distributions. Additionally, a design feature is desired which will aid in the derivation of tailor made multiple sampling plans with variable incremental sample sizes which will allow the user to constrain the total number sampled at specified risk levels.

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APPENDIX A
LAVAS's SOURCE CODE

APPENDIX A
LAVAS's SOURCE CODE

```
10     PRINTER IS 0
20     DIM Pa(10,301),Asn(301),Dist$[15],Pd(301),F(10),Jmc(31,9),Con(501),Conp(50
1),Pr(5,501),Cont(501),Ccea(2,17,8),Mila(17,2),Milr(17,2),Mils(17)
30     DIM S105s(17),S105c(15),Num$(102)[3],Tab$(20)[3],Table(501,3),Multi(50,13)
,Fig(51,501),Figp(51,501),Lima(51)
40     DIM Ccmt(20,24),Msplar(15,7,2),Msplan(30)
50     DATA "  1","  2","  3","  4","  5","  6","  7","  8","  9"," 10"," 11"," 1
2"," 13"," 14"," 15"," 16"," 17"," 18"," 19"," 20"," 21"," 22"," 23"," 24"
60     DATA " 25"," 26"," 27"," 28"," 29"," 30"," 31"," 32"," 33"," 34"," 35"," 3
6"," 37"," 38"," 39"," 40"," 41"," 42"," 43"," 44"," 45"," 46"," 47"," 48"," 49"
70     DATA " 50"," 51"," 52"," 53"," 54"," 55"," 56"," 57"," 58"," 59"," 60"," 6
1"," 62"," 63"," 64"," 65"," 66"," 67"," 68"," 69"," 70"," 71"," 72"," 73"," 74"
80     DATA " 75"," 76"," 77"," 78"," 79"," 80"," 81"," 82"," 83"," 84"," 85"," 8
6"," 87"," 88"," 89"," 90"," 91"," 92"," 93"," 94"," 95"," 96"," 97"," 98"," 99"
90     DATA "100","  0","***"
100    FOR I=1 TO 102
110    READ Num$(I)
120    NEXT I
130    BEEP
140    FOR I=1 TO 31
150    FOR J=1 TO 9
160    READ Jmc(I,J)
170    NEXT J
180    BEEP
190    NEXT I
200    DATA 0,.01,.051,.105,.693,2.303,2.996,4.605,44.89
210    DATA 1,.149,.355,.532,1.678,3.89,4.744,6.638,10.946
220    DATA 2,.436,.818,1.102,2.674,5.322,6.296,8.406,6.509
230    DATA 3,.823,1.366,1.745,3.672,6.681,7.754,10.045,4.89
240    DATA 4,1.279,1.97,2.433,4.671,7.994,9.154,11.605,4.057
250    DATA 5,1.705,2.613,3.152,5.67,9.275,10.513,13.108,3.549
260    DATA 6,2.33,3.286,3.895,6.67,10.532,11.842,14.571,3.206
270    DATA 7,2.986,3.981,4.656,7.669,11.771,13.148,16,2.957
280    DATA 8,3.587,4.695,5.432,8.669,12.995,14.434,17.483,2.768
290    DATA 9,4.13,5.426,6.221,9.669,14.286,15.705,18.783,2.618
300    DATA 10,4.771,6.169,7.021,10.668,15.487,16.962,20.145,2.497
310    DATA 11,5.428,6.924,7.829,11.668,16.598,18.288,21.49,2.397
320    DATA 12,6.099,7.69,8.646,12.668,17.782,19.442,22.821,2.312
330    DATA 13,6.782,8.464,9.47,13.668,18.958,20.668,24.139,3.24
340    DATA 14,7.477,9.246,10.3,14.668,20.128,21.886,25.446,2.177
350    DATA 15,8.181,10.035,11.135,15.668,21.292,23.098,26.743,2.122
360    DATA 16,8.895,10.831,11.976,16.668,22.452,24.302,28.031,2.073
370    DATA 17,9.616,11.633,12.822,17.668,23.606,25.5,29.31,2.029
380    DATA 18,10.346,12.442,13.672,18.668,24.756,26.692,30.581,1.99
390    DATA 19,11.082,13.254,14.525,19.668,25.902,27.879,31.845,1.954
400    DATA 20,11.825,14.072,15.383,20.668,27.045,29.062,33.103,1.922
410    DATA 21,12.574,14.894,16.244,21.668,28.184,30.241,34.355,1.892
420    DATA 22,13.329,15.719,17.108,22.668,29.32,31.416,35.601,1.865
430    DATA 23,14.088,16.548,17.975,23.668,30.453,32.586,36.841,1.84
440    DATA 24,14.853,17.382,18.844,24.668,31.584,33.752,38.077,1.817
450    DATA 25,15.623,18.218,19.717,25.667,32.711,34.916,39.308,1.795
460    DATA 30,19.532,22.444,24.113,30.667,38.315,40.69,45.4,1.707
470    DATA 35,23.525,26.731,28.556,35.667,43.872,46.404,51.409,1.641
480    DATA 40,27.587,31.066,33.038,40.667,49.39,52.069,57.347,1.59
490    DATA 45,31.704,35.441,37.550,45.667,54.878,57.695,63.231,1.548
500    DATA 50,35.867,39.849,42.089,50.667,60.339,63.287,69.066,1.515
510    FOR I=1 TO 2
520    IF I=1 THEN Lim=16
530    IF I=2 THEN Lim=17
540    FOR J=1 TO Lim
550    FOR K=1 TO 8
560    READ Ccea(I,J,K)
570    NEXT K
580    NEXT J
590    BEEP
600    NEXT I
610    FOR I=1 TO 16
620    READ Mila(I,1),Mila(I,2),Milr(I,1),Milr(I,2)
630    NEXT I
640    FOR I=1 TO 16
650    READ Mils(I)
660    NEXT I
670    BEEP
```

```
680   DATA 1,14.5,0,1,.16,.84,2.32,1.273,2,8.07,0,2,.3,1.07,2.42,1.511
690   DATA 3,6.48,1,3,.6,1.0,3.09,1.238,4,5.39,0,3,.49,1.35,2.64,1.771,5,5.09,1,
4,.77,1.97,3.92,1.359
700   DATA 6,4.31,0,4,.68,1.64,2.93,1.985,7,4.19,1,5,.96,2.10,4.02,1.498,8,3.6,1
,6,1.16,2.44,4.17,1.646,9,3.26,2,8,1.68,3.20,5.47,1.476
710   DATA 10,2.96,3,10,2.27,4.13,6.72,1.380,11,2.77,3,11,2.46,4.36,6.82,1.468,1
2,2.62,4,13,3.07,5.21,8.05,1.394,13,2.46,4,14,3.29,5.4,8.11,1.472
720   DATA 14,2.21,3,15,3.41,5.4,7.55,1.808,15,1.97,4,20,4.75,7.02,9.35,2.029,16
,1.74,6,30,7.45,10.31,12.96,2.23
730   DATA 1,11.9,0,1,.21,1,2.5,1.17,2,7.54,1,2,.52,1.02,3.92,1.081,3,6.79,0,2,.
43,1.42,2.96,1.34,4,5.39,1,3,.76,2.11,4.11,1.169,5,4.65,2,4,1.16,2.9,5.39,1.105
740   DATA 6,4.25,1,4,1.04,2.5,4.42,1.274,7,3.80,2,5,1.43,3.2,5.55,1.17,8,3.63,3
,6,1.87,3.90,6.78,1.117,9,3.38,2,6,1.72,3.56,5.82,1.248
750   DATA 10,3.21,3,7,2.15,4.27,6.91,1.173,11,3.09,4,8,2.62,5.02,8.1,1.124,12,2
.85,4,9,2.9,5.33,8.26,1.167,13,2.6,5,11,3.60,6.4,9.56,1.166
760   DATA 14,2.44,5,12,4,6.73,9.77,1.215,15,2.32,5,13,4.35,7.06,10.28,1.271,16,
2.22,5,14,4.7,7.52,10.45,1.331,17,2.12,5,16,5.39,8.4,11.41,1.452
770   DATA 0,1,2,2,0,3,3,4,1,4,4,5,2,6,5,7,3,8,7,9,3,11,7,12,5,12,9,13,6,15,10,1
6,7,18,11,19,9,23,14,24,11,26,16,27,13,34,20,35,15,34,20,35,17,37,22,38
780   DATA 23,52,29,53,25,56,31,57
790   DATA 2,3,5,8,13,20,32,50,80,125,200,315,500,800,1250,2000
800   DATA 2,3,5,8,13,20,32,50,80,125,200,315,500,800,1250,2000,3150
810   DATA 1,2,3,5,7,8,10,12,14,18,21,27,30,41,44
820   DATA 1,10.46,-5,-5,0,0,1,2,3,100,100
830   DATA 2,2,2,2,3,4,4,100,100
840   DATA .048,.38,.89,3.243
850   DATA 2,12.15,-5,-5,-5,0,0,1,2,100,100
860   DATA 2,2,2,2,2,3,3,100,100
870   DATA .065,.31,.79,4.373
880   DATA 3,9.95,-5,-5,0,0,1,2,4,100,100
890   DATA 2,2,2,3,3,4,5,100,100
900   DATA .1,.43,1,3.461
910   DATA 4,8.91,-5,-5,0,0,0,0,0,2,100,2,2,2,2,2,3,3,3,100,.080,.34,.78,3.876
920   DATA 5,8.06,-5,-5,0,0,0,0,0,1,2,2,2,2,3,3,3,3,3,3,.093,.36,.75,4.077
930   DATA 6,7.04,-5,0,0,1,1,1,2,3,100,2,3,3,3,4,4,4,4,100,.18,.62,1.27,2.828
940   DATA 7,6.20,-5,0,1,1,2,3,4,100,100,2,3,3,3,4,5,5,100,100,.24,.74,1.48,2.51
5
950   DATA 8,4.95,-5,0,1,2,4,4,5,100,100,2,3,4,5,6,6,6,100,100,.31,.84,1.55,2.60
6
960   DATA 9,4.61,-5,0,0,1,2,3,4,6,100,3,3,4,4,5,6,7,7,100,.31,.78,1.43,3.268
970   DATA 10,4.29,0,2,3,5,7,8,10,100,100,4,5,7,9,10,11,11,100,100,.68,1.73,2.93
,1.727
980   DATA 11,4.02,-5,1,2,3,4,6,7,100,100,3,4,5,6,6,8,8,100,100,.47,1.14,1.89,2.
308
990   DATA 12,3.75,-5,1,1,2,3,5,7,100,100,3,4,5,6,6,8,8,100,100,.56,1.23,2.11,2.
839
1000  DATA 13,3.56,-5,1,1,3,4,5,7,9,100,3,5,6,7,8,9,10,10,100,.59,1.26,2.10,2.87
2
1010  DATA 14,3.23,0,2,3,4,6,8,11,100,100,4,5,8,9,10,12,12,100,100,.96,1.92,3.10
,2.210
1020  DATA 15,3.03,0,3,6,8,10,12,14,100,100,4,7,9,11,12,14,15,100,100,1.2,2.34,3
.64,1.891
1030  DATA 16,2.69,1,3,6,9,11,14,17,100,100,5,7,10,13,15,18,18,100,100,1.56,2.75
,4.20,1.839
1040  DATA 17,2.54,1,3,6,9,13,16,18,100,100,5,8,11,13,16,18,19,100,100,1.60,2.83
,4.06,1.911
1050  DATA 18,2.35,1,5,7,10,13,17,22,100,100,6,9,12,16,19,21,23,100,100,2.00,3.3
4,4.70,1.982
1060  DATA 19,2.16,1,5,9,13,18,22,25,100,100,7,10,13,18,22,25,26,100,100,2.40,3.
77,5.19,2.130
1070  DATA 20,1.94,3,8,13,18,24,30,36,100,100,8,15,20,25,30,34,37,100,100,3.74,5
.46,7.26,1.967
1080  DATA -5,-5,0,0,1,1,2,2,2,2,3,3,3,3
1090  DATA -5,0,0,1,2,3,4,2,3,3,4,4,5,5
1100  DATA -5,0,1,2,3,4,6,3,3,4,5,6,6,7
1110  DATA -5,1,2,3,5,7,9,4,5,6,7,8,9,10
1120  DATA 0,1,3,5,7,10,13,4,6,8,10,11,12,14
1130  DATA 0,2,4,6,9,12,14,4,7,9,11,12,14,15
1140  DATA 0,3,6,8,11,14,18,5,8,10,13,15,17,19
1150  DATA 0,3,7,10,14,18,21,6,9,12,15,17,20,22
1160  DATA 1,4,8,12,17,21,25,7,10,13,17,20,23,26
1170  DATA 1,6,11,16,22,27,32,8,12,17,22,25,29,33
1180  DATA 2,7,13,19,25,31,37,9,14,19,25,29,33,38
1190  DATA 3,10,17,24,32,40,48,10,17,24,31,37,43,49
1200  DATA 4,11,19,27,36,45,53,12,19,27,34,40,47,54
```

```
1210  DATA 6,16,26,37,49,61,72,15,25,36,46,55,64,73
1220  DATA 6,17,29,40,53,65,77,16,27,39,49,58,68,78
1230  DATA 2,3,4,5,6,7,8,9,10,11,12,13,14,15,18,20,24,32,36,48,50
1240  FOR I=1 TO 17
1250  READ S105s(I)
1260  NEXT I
1270  FOR I=1 TO 15
1280  READ S105c(I)
1290  NEXT I
1300  BEEP
1310  FOR I=1 TO 20
1320  FOR J=1 TO 24
1330  READ Ccmt(I,J)
1340  NEXT J
1350  BEEP
1360  DISP
1370  NEXT I
1380  FOR I=1 TO 15
1390  FOR J=1 TO 7
1400  READ Msplar(I,J,1)
1410  NEXT J
1420  FOR J=1 TO 7
1430  READ Msplar(I,J,2)
1440  NEXT J
1450  BEEP
1460  NEXT I
1470  FOR I=1 TO 21
1480  READ Msplan(I)
1490  NEXT I
1500  BEEP
1510  DISP
1520  DISP "
1530  DISP "
"
1540  DISP "                LOT ACCEPTANCE SAMPLING OPTIONS
"
1550  DISP "    Option Description                                   Select Code
"
1560  DISP "    >Single Sampling Design And Assessment..............1
"
1570  DISP "    >Double Sampling Design And Assessment..............2
"
1580  DISP "    >Multiple Sampling Design And Assessment............3
"
1590  DISP "    >Sequential Sampling Design And Assessment..........4
"
1600  DISP "    >Truncated Sequential Sampling or Any Convergent
"
1610  DISP "     Plan Assessment(i.e., OC Curve & ASN Curve)........5
"
1620  DISP "    >Program Termination................................6
"
1630  DISP "
1640  DISP
1650  DISP "ENTER THE SELECT CODE OF THE DESIRED OPTION."
1660  DISP
1670  BEEP
1680  INPUT Sc
1690  IF Sc=6 THEN DISP
1700  IF Sc=6 THEN DISP "Bye Bye!"
1710  IF Sc=6 THEN DISP
1720  IF Sc=6 THEN BEEP
1730  IF Sc=6 THEN STOP
1740  DISP
1750  DISP "          LOADING SELECTED OPTION!      "
1760  DISP
1770  IF Sc=1 THEN LINK "Single:C12",2000
1780  IF Sc=2 THEN LINK "Double:C12",2000
1790  IF Sc=3 THEN LINK "Multi:C12",2000
1800  IF Sc=4 THEN LINK "Seque:C12",2000
1810  IF Sc=5 THEN LINK "Spec:C12",2000
1820  IF (Sc=1) OR (Sc=2) OR (Sc=3) OR (Sc=4) OR (Sc=5) THEN 1960
1830  FOR I=1 TO 11
1840  DISP
```

```
1850  DISP "
1860  DISP "                                                        "
1870  DISP "
1880  DISP
1890  DISP "                                                         "
1900  DISP "                                                         "
1910  DISP "                                                         "
1920  DISP
1930  BEEP
1940  INPUT R$
1950  GOTO 1510
1960  GOSUB 2000
1970  STOP
```

APPENDIX B
SINGLE SAMPLING DESIGN AND ASSESSMENT SOURCE CODE

APPENDIX B
SINGLE SAMPLING DESIGN AND ASSESSMENT SOURCE CODE

```
2000  REM            **** SINGLE SAMPLE DESIGN AND/OR RISK ASSESSMENT ****
2010  DISP
2020  DISP "
2030  DISP "                 > Single Sampling Plan Option Menu <
"
2040  DISP "    Option Description                                    Select Code
"
2050  DISP "   >OC Curve/Risk Assessment for a Specific Plan........1
"
2060  DISP "   >Plan Derivation for Given AQL, LTPD, ALPHA & BETA...2
"
2070  DISP "   >Plan Derivation for a Single Point of Control at
"
2080  DISP "    the Indifference Quality (Poisson Based)............3
"
2090  DISP "   >Plan Derivation Using J.M. Cameron's Poisson
"
2100  DISP "    Approximation of the OC Curve.......................4
"
2110  DISP "   >Plan Der'vation Via MIL-STD-105D Search for
"
2120  DISP "    Specifi~  AQL, LTPD, ALPHA, & BETA..................5
"
2130  DISP "    EXIT This Segment of the Program....................6
"
2140  DISP "
2150  DISP "ENTER THE SELECT CODE OF THE DESIRED OPTION."
2160  DISP
2170  BEEP
2180  INPUT Sc
2190  IF Sc=6 THEN RETURN
2200  IF Sc<>1 THEN 4890
2210  DISP
2220  DISP "                 ENTER THE SAMPLE SIZE!"
2230  DISP
2240  BEEP
2250  INPUT Sample
2260  DISP
2270  DISP "                 ENTER THE THE ACCEPTANCE NUMBER!"
2280  DISP
2290  BEEP
2300  INPUT Accept
2310  DISP
2320  DISP "                 DO YOU HAVE A FINITE LOT SIZE?"
2330  DISP
2340  BEEP
2350  INPUT Res$
2360  IF Res$="NO" THEN Dist$="BINOMIAL"
2370  IF Res$="NO" THEN 2550
2380  DISP
2390  DISP "    ENTER THE FINITE LOT SIZE "
2400  DISP
2410  BEEP
2420  INPUT Lsize
2430  Ratio=Sample/Lsize
2440  IF Ratio>=.1 THEN Dist$="HYPER"
2450  IF Ratio>=.1 THEN 3790
2460  DISP
2470  DISP "Since the ratio of sample size to lot size is less than ten percent,
"
2480  DISP "it maybe acceptable to use a Binomial Approximation to the Hypergeom
etric."
2490  DISP "DO YOU WISH TO USE THIS APPROXIMATION?"
2500  DISP
2510  BEEP
2520  INPUT Res$
2530  IF Re$="NO" THEN Dist$="HYPER"
2540  IF Re$="YES" THEN Dist$="BINOMIAL"
2550  IF Dist$="HYPER" THEN 3790
2560  S=Sample
2570  P=.001
2580  C=Accept
2590  FOR X=0 TO C
2600  GOSUB 2680
2610  IF X=0 THEN Pacpt=Prob
2620  IF X<>0 THEN Pacpt=Pacpt+Prob
2630  NEXT X
```

```
2640  IF Pacpt<.02 THEN 2810
2650  P=P+.001
2660  BEEP
2670  GOTO 2590
2680  REM BINOMIAL SUBROUTINE
2690  IF (S-X<0) OR (X<0) THEN Prob=0
2700  IF (S-X<0) OR (X<0) THEN RETURN
2710  IF (S-X=0) OR (X=0) THEN Prob=P^X*(1-P)^(S-X)
2720  IF (S-X=0) OR (X=0) THEN RETURN
2730  Prob=1
2740  FOR Is=1 TO X
2750  Prob=Prob*P
2760  NEXT Is
2770  FOR Is=1 TO S-X
2780  Prob=Prob*((X+Is)/Is)*(1-P)
2790  NEXT Is
2800  RETURN
2810  DISP
2820  DISP "The probability of Acceptance is ";Pacpt*100;"% at Percent Defective
"
2830  DISP "equal to ";P*100;"%."
2840  DISP
2850  DISP "What range do you want to include on the OC Curve's Percent Defectiv
e Axis?"
2860  DISP "The entry must be stated as a percent(i.e., fifty percent's entry i
s 50)."
2870  DISP
2880  BEEP
2890  INPUT Maxx
2900  Maxx=Maxx+1
2910  DISP
2920  DISP "ENTER THE DESIRED LABELING INTERVAL ON THE PERCENT DEFECTIVE AXIS."
2930  DISP "The entry must be stated as a percent(i.e., five percent's entry is
 5)."
2940  DISP
2950  BEEP
2960  INPUT Xint
2970  Inc=Maxx/100
2980  FOR I=1 TO 100
2990  Pd(I)=I*Inc
3000  P=Pd(I)/100
3010  C=Accept
3020  S=Sample
3030  FOR X=0 TO C
3040  GOSUB 2680
3050  IF X=0 THEN Pa(1,I)=Prob
3060  IF X<>0 THEN Pa(1,I)=Prob+Pa(1,I)
3070  NEXT X
3080  NEXT I
3090  Lim=100
3100  GOSUB 4640
3110  DISP
3120  DISP "DO YOU WANT ANY SPECIFIC POINTS PRINTED?"
3130  DISP
3140  BEEP
3150  INPUT Res
3160  IF Res="NO" THEN 2810
3170  PRINT LIN(4);SPA(10);"Operating Characteristic (OC) Curve "
3180  PRINT SPA(10);"Single Sampling Plan : n = ";"Sample ";" &  C = ";Accept
3190  PRINT SPA(17);"(Binomial Distribution Probabilities)";LIN(1)
3200  PRINT USING 3260
3210  PRINT USING 3240
3220  PRINT USING 3250
3230  PRINT USING 3260
3240  IMAGE 20X,"| Percent | Probability |"
3250  IMAGE +,20X,"|Defective|of Acceptance|"
3260  IMAGE 20X,"_______________________"
3270  IMAGE +,20X,"|",4D.4D,"|",8D.4D,"|"
3280  DISP
3290  DISP "ENTER THE PERCENT DEFECTIVE....."
3300  DISP
3310  BEEP
3320  INPUT P
3330  P=P/100
3340  FOR X=0 TO C
3350  GOSUB 2680
```

```
3360  IF X=0 THEN Pacpt=Prob
3370  IF X<>0 THEN Pacpt=Prob+Pacpt
3380  NEXT X
3390  PRINT USING 3270;P*100,Pacpt*100
3400  PRINT USING 3260
3410  DISP
3420  DISP "    DO YOU WANT ANYMORE?   "
3430  DISP
3440  BEEP
3450  INPUT Res
3460  IF Res="NO" THEN 2010
3470  GOTO 3200
3480  REM HYPERGEOMETRIC DISTRIBUTION
3490  IF X<0 THEN Prob=0
3500  IF X<0 THEN RETURN
3510  IF X>M THEN Prob=0
3520  IF X>M THEN RETURN
3530  Prob=1
3540  F(1)=K
3550  F(2)=N-K
3560  F(3)=M
3570  F(4)=N-M
3580  F(5)=X
3590  F(6)=K-X
3600  F(7)=M-X
3610  F(8)=N-K-M+X
3620  F(9)=N
3630  FOR Is=1 TO 9
3640  IF F(Is)<1 THEN F(Is)=1
3650  NEXT Is
3660  Prob=Prob*F(1)*F(2)*F(3)*F(4)/(F(5)*F(6)*F(7)*F(8)*F(9))
3670  FOR Is=1 TO 9
3680  F(Is)=F(Is)-1
3690  IF F(Is)<1 THEN F(Is)=1
3700  NEXT Is
3710  Ck=0
3720  FOR Is=1 TO 9
3730  IF F(Is)=1 THEN 3750
3740  Ck=1
3750  NEXT Is
3760  IF Ck=0 THEN RETURN
3770  GOTO 3660
3780  RETURN
3790  M=Sample
3800  K=1
3810  C=Accept
3820  N=Lsize
3830  FOR X=0 TO C
3840  GOSUB 3480
3850  IF X=0 THEN Pacpt=Prob
3860  IF X<>0 THEN Pacpt=Pacpt+Prob
3870  IF Pacpt>1 THEN Pacpt=1
3880  NEXT X
3890  DISP "K=";K;" is Done! Pa=";Pacpt
3900  IF Pacpt<.02 THEN 3940
3910  K=K+1
3920  BEEP
3930  GOTO 3830
3940  DISP
3950  DISP "The probability of Acceptance is ";Pacpt*100;"% for ";K;"Defectives"
3960  DISP "in the lot."
3970  DISP
3980  DISP "What range do you want to include on the OC Curve's Defectives Per L
ot Axis?"
3990  DISP "The entry must be stated as an integer.
"
4000  DISP
4010  BEEP
4020  INPUT Maxx
4030  Maxx=Maxx+1
4040  DISP
4050  DISP "ENTER THE DESIRED LABELING INTERVAL ON THE DEFECTIVES PER LOT AXIS."
4060  DISP "The entry must be stated as an integer.
"
4070  DISP
4080  BEEP
```

```
4090 INPUT Xint
4100 IF Maxx>100 THEN Lim=100
4110 IF Maxx<100 THEN Lim=Maxx
4120 FOR I=1 TO Lim
4130 Pd(I)=I
4140 K=Pd(I)
4150 C=Accept
4160 N=Lsize
4170 S=Sample
4180 FOR X=0 TO C
4190 GOSUB 3400
4200 IF X=0 THEN Pa(1,I)=Prob
4210 IF X<>0 THEN Pa(1,I)=Prob+Pa(1,I)
4220 IF Pa(1,I)>1 THEN Pa(1,I)=1
4230 NEXT X
4240 DISP "Worked K = ";K
4250 NEXT I
4260 GOSUB 4640
4270 DISP
4280 DISP "DO YOU WANT ANY SPECIFIC POINTS PRINTED?"
4290 DISP
4300 BEEP
4310 INPUT Res$
4320 IF Res$="NO" THEN 2010
4330 PRINT LIN(4);SPA(10);"Operating Characteristic (OC) Curve "
4340 PRINT SPA(12);"Single Sampling Plan : n = ";Sample;" &  C = ";Accept
4350 PRINT SPA(14);"(Hypergeometric Distribution Probabilities)";LIN(1)
4360 PRINT USING 4420
4370 PRINT USING 4400
4380 PRINT USING 4410
4390 PRINT USING 4420
4400 IMAGE 20X,"|Defectives| Probability |"
4410 IMAGE +,20X,"| Per Lot  |of Acceptance|"
4420 IMAGE 20X,"__________________________"
4430 IMAGE +,20X,"|",3X,4D,3X,"|",8D.4D,"|"
4440 DISP
4450 DISP "ENTER THE NUMBER OF DEFECTIVES PER LOT...."
4460 DISP
4470 BEEP
4480 INPUT K
4490 FOR X=0 TO C
4500 GOSUB 3400
4510 IF X=0 THEN Pacpt=Prob
4520 IF X<>0 THEN Pacpt=Prob+Pacpt
4530 IF Pacpt>1 THEN Pacpt=1
4540 NEXT X
4550 PRINT USING 4430;K,Pacpt*100
4560 PRINT USING 4420
4570 DISP
4580 DISP "    DO YOU WANT ANYMORE?   "
4590 DISP
4600 BEEP
4610 INPUT Res$
4620 IF Res$="NO" THEN 2010
4630 GOTO 4440
4640 REM OC CURVE
4650 PLOTTER IS "9872
4660 PLOTTER 7,5 IS ON
4670 LOCATE 10,100,10,100
4680 SCALE 0,Maxx,0,104
4690 CSIZE 2
4700 LAXES Xint,5,0,0,-1,1
4710 MOVE 2*Xint,101
4720 LABEL "      Operating Characteristic Curve"
4730 LABEL "Sample Size:";Sample;"Acceptance Number:";C
4740 IF Dist$="HYPER" THEN LABEL "      Hypergeometric Probabilities"
4750 IF Dist$="BINOMIAL" THEN LABEL "        Binomial Probabilities"
4760 PEN 2
4770 MOVE 0,100
4780 FOR I=1 TO Lim
4790 DRAW Pd(I),Pa(1,I)*100
4800 NEXT I
4810 PEN 1
4820 MOVE 4*Xint,-5
4830 IF Dist$="BINOMIAL" THEN LABEL "PERCENT DEFECTIVE"
4840 IF Dist$="HYPER" THEN LABEL "DEFECTIVES PER LOT"
4850 MOVE Xint/4,101
```

```
4860  LABEL "Pa(%)"
4870  MOVE 120,120
4880  RETURN
4890  IF Sc<>3 THEN 5220
4900  REM Point of Control at Indifference Quality
4910  DISP
4920  DISP "                        ENTER THE INDIFFERENCE QUALITY...."
4930  DISP "                    ENTER THIS PERCENT DEFECTIVE AS A PERCENT. "
4940  DISP
4950  BEEP
4960  INPUT P50p
4970  P50p=P50p/100
4980  FOR C=0 TO 50
4990  Asn(C+1)=(C+.67)/P50p
5000  Ck=INT(Asn(C+1))
5010  IF Asn(I)>Ck THEN Asn(I)=Ck+1
5020  Pa(S,C+1)=C
5030  NEXT C
5040  IMAGE 25X,"Single Sample Sampling Plans"
5050  IMAGE 20X,"For An Indifference Quality of ",3D.2D,"%"
5060  IMAGE 10X," ____________________________________________________________ "
5070  IMAGE 10X,"|Sample|Acceptance|Sample|Acceptance|Sample|Acceptance|"
5080  IMAGE 10X,"| Size |  Number  | Size |  Number  | Size |  Number  |"
5090  IMAGE +,10X,"|",3(1X,4D,1X,"|",3X,4D,3X,"|")
5100  PRINT LIN(4)
5110  PRINT USING 5040
5120  PRINT USING 5050;P50p*100
5130  PRINT USING 5060
5140  PRINT USING 5070
5150  PRINT USING 5080
5160  FOR I=1 TO 17
5170  PRINT USING 5090;Asn(I),Pa(S,I),Asn(I+17),Pa(S,I+17),Asn(I+34),Pa(S,I+34)
5180  PRINT USING 5060
5190  NEXT I
5200  PRINT LIN(2);SPA(10);"Any of these plans can be evaluated by exercising Op
tion #1";LIN(4)
5210  GOTO 2010
5220  IF Sc<>4 THEN 5850
5230  DISP
5240  DISP " DO YOU HAVE A QUALITY LEVEL AT WHICH YOU WISH A 99%, 95%, 90%, 50%
, 10%   "
5250  DISP " 5% OR 1% PROBABILITY OF ACCEPTANCE.
      "
5260  DISP
5270  BEEP
5280  INPUT R$
5290  IF R$="NO" THEN 5780
5300  DISP
5310  DISP " ENTER THE QUALITY LEVEL AND THE PROBABILITY OF ACCEPTANCE AT THAT
"
5320  DISP " QUALITY LEVEL.   BOTH ENTRIES MUST BE STATED AS PERCENTS.
  "
5330  BEEP
5340  INPUT Perc,Pofa
5350  Perc=Perc/100
5360  Pofa=Pofa/100
5370  IF Pofa=.99 THEN Col=2
5380  IF Pofa=.95 THEN Col=3
5390  IF Pofa=.9 THEN Col=4
5400  IF Pofa=.50 THEN Col=5
5410  IF Pofa=.1 THEN Col=6
5420  IF Pofa=.05 THEN Col=7
5430  IF Pofa=.01 THEN Col=8
5440  PRINT LIN(4)
5450  IMAGE 25X,"Single Sample Sampling Plans"
5460  IMAGE 20X,"J.M. Cameron's Poisson Approximations"
5470  IMAGE 17X,"Where The Probability of Acceptance is",3D.2D,"%"
5480  IMAGE 19X,"When The Percent Defective is ",3D.2D,"%",/
5490  PRINT USING 5450
5500  IMAGE "                    __________________________________________
__________"
5510  IMAGE "_____________|Percent Defective Specifications For Which The
 Poisson |"
5520  IMAGE "__________________________________________________________
__________"
```

```
5530  IMAGE "|Sample|Acceptance|   Approximation Of the Probability of Acceptan
ce is     |"
5540  IMAGE "| Size |  Number  |  99%  |  95%  |  90%  |  50%  |  10%  |   5%
|    1%   |"
5550  IMAGE +,"|",1X,4D,1X,"|",4X,2D,4X,"|",7(4D.2D,"|")
5560  PRINT USING 5460
5570  PRINT USING 5470;Pofa*100
5580  PRINT USING 5480;Pert*100
5590  PRINT USING 5500
5600  PRINT USING 5510
5610  PRINT USING 5530
5620  PRINT USING 5540
5630  FOR I=1 TO 31
5640  F(2)=Jmc(I,1)
5650  Sam=Jmc(I,Col)/Pert
5660  Ck=INT(Sam)
5670  IF Sam>Ck THEN Sam=Ck+1
5680  F(1)=Sam
5690  F(2)=Jmc(I,1)
5700  FOR J=2 TO 8
5710  F(J+1)=100*Jmc(I,J)/Sam
5720  NEXT J
5730  PRINT USING 5550;F(1),F(2),F(3),F(4),F(5),F(6),F(7),F(8),F(9)
5740  PRINT USING 5520
5750  NEXT I
5760  PRINT LIN(2);SPA(10);"Any of these plans can be evaluated by exercising Op
tion 01";LIN(4)
5770  GOTO 2010
5780  DISP
5790  DISP "  TO EXERCISE THIS OPTION, YOU MUST ENTER ONE OF THE OPTIONAL POINT
S SPECIFIED!"
5800  DISP
5810  BEEP
5820  DISP "                              TRY AGAIN!  "
5830  BEEP
5840  GOTO 2010
5850  IF Sc<>2 THEN 6810
5860  DISP
5870  FOR I=1 TO 6
5880  IF I=1 THEN DISP "  Enter the Acceptable Quality Level, STATED AS A PERC
ENT!  "
5890  IF I=2 THEN DISP "  Enter the Lot Tolerance Percent Defective,STATED AS
A PERCENT!  "
5900  IF I=3 THEN DISP "  Enter the Producer's Risk,STATED AS A PERCENT!  "
5910  IF I=4 THEN DISP "  Enter the Consumer's Risk,STATED AS A PERCENT!  "
5920  IF I=5 THEN DISP "  Enter the Producer's Risk Tolerance limit,STATED AS
A PERCENT!  "
5930  IF I=6 THEN DISP "  Enter the Consumer's Risk Tolerance limit,STATED AS
A PERCENT!  "
5940  DISP
5950  BEEP
5960  IF I=1 THEN INPUT Aql
5970  IF I=2 THEN INPUT Ltpd
5980  IF I=3 THEN INPUT Alpha
5990  IF I=4 THEN INPUT Beta
6000  IF I=5 THEN INPUT Atol
6010  IF I=6 THEN INPUT Btol
6020  NEXT I
6030  Aql=Aql/100
6040  Ltpd=Ltpd/100
6050  Alpha=Alpha/100
6060  Beta=Beta/100
6070  Btol=Btol/100
6080  Atol=Atol/100
6090  Print=0
6100  Maxn=1000000
6110  DISP
6120  DISP "    DO YOU HAVE A MAXIMUM SAMPLE SIZE?   "
6130  DISP
6140  BEEP
6150  INPUT Res
6160  IF Res="NO" THEN 6220
6170  DISP
6180  DISP "                    ENTER THE MAXIMUM SAMPLE SIZE"
6190  DISP
6200  BEEP
```

```
6210  INPUT Maxn
6220  IMAGE /,/,/,/,10X,"Optional Single Sampling Plans Which  "
6230  IMAGE 10X,"Producer's Risk = ",3D.2D,"+",3D.2D,"%",/,10X,"Consumer's Ris
k = ",3D.2D,"+",3D.2D,"%",/,10X,"For AQL=",3D.2D,"% & LTPD=",3D.2D,"%",/
6240  IMAGE 10X,"                                                  "
6250  IMAGE 10X,"|Sample|Acceptance|Producer's|Consumer's|"
6260  IMAGE 10X,"| Size |  Number  |   Risk   |   Risk   |"
6270  IMAGE +,10X,"|",6D,"|",3X,4D,3X,"|",2X,3D.2D,"%",1X,"|"2X,3D.2D,"%",1X,"|"
6280  Dist$="BINOMIAL"
6290  PRINT USING 6220
6300  PRINT USING 6230;Alpha*100,Atol*100,Beta*100,Btol*100,Aql*100,Ltpd*100
6310  PRINT SPA(12);"(Binomial Probabilities)"
6320  PRINT USING 6240
6330  PRINT USING 6250
6340  PRINT USING 6260
6350  REM ***** HOLDING ALPHA  *****
6360  C=0
6370  Sample=1
6380  BEEP
6381  IF Sample>Maxn THEN 6620
6390  Pap=1/EXP(Sample*Aql)
6400  Ck=1-Pap
6410  Ck2=Alpha-Atol
6420  IF Ck2<=0 THEN Ck2=.005
6430  IF Ck<Ck2 THEN 6460
6440  Sample=Sample+1
6450  GOTO 6380
6460  IF Sample<10 THEN Low=C+1
6470  IF Sample>=10 THEN Low=Sample-10
6480  FOR S=Low TO Sample+1000
6490  P=Aql
6500  X=0
6510  GOSUB 2600
6520  Prisk=1-Prob
6530  P=Ltpd
6540  X=0
6550  GOSUB 2600
6560  Crisk=Prob
6570  IF (ABS(Prisk-Alpha)<=Atol) AND (ABS(Crisk-Beta)<=Btol) THEN PRINT USING 6
270;S,C,Prisk*100,Crisk*100
6580  IF (ABS(Prisk-Alpha)<=Atol) AND (ABS(Crisk-Beta)<=Btol) THEN Print=Print+1
6590  IF (ABS(Prisk-Alpha)<=Atol) AND (ABS(Crisk-Beta)<=Btol) THEN PRINT USING 6
240
6600  IF Crisk<Beta-Btol+.004 THEN 6620
6610  NEXT S
6620  FOR C=1 TO 50
6630  Sample=C+1
6640  IF Sample>Maxn THEN 7110
6650  Pap=1/EXP(Sample*Aql)
6660  Cum=Pap
6670  FOR Pass=1 TO C
6680  Pap=Pap*Sample*Aql/Pass
6690  Cum=Cum+Pap
6700  IF Cum>1 THEN Cum=1
6710  NEXT Pass
6720  Ck=Alpha
6730  Prisk=1-Cum
6740  IF Prisk<=Ck2 THEN 6780
6750  Sample=Sample+1
6760  IF Sample>Maxn THEN 7110
6770  GOTO 6640
6780  IF Sample>Maxn THEN 7110
6790  IF Sample<25 THEN Low=C+1
6800  IF Sample>25 THEN Low=Sample-25
6810  FOR S=Low TO Sample+1000
6820  IF S>Maxn THEN 7040
6830  P=Aql
6840  FOR X=0 TO C
6850  GOSUB 2600
6860  IF X=0 THEN Prisk=Prob
6870  IF X<>0 THEN Prisk=Prob+Prisk
6880  IF Prisk>1 THEN Prisk=1
6890  NEXT X
6900  Prisk=1-Prisk
6910  P=Ltpd
6920  FOR X=0 TO C
```

```
6930  GOSUB 2600
6940  IF X=0 THEN Crisk=Prob
6950  IF X<>0 THEN Crisk=Prob+Crisk
6960  IF Crisk>1 THEN Crisk=1
6970  NEXT X
6980  BEEP
6990  IF (ABS(Prisk-Alpha)<=Atol) AND (ABS(Crisk-Beta)<=Btol) THEN PRINT USING 6
270;S,C,Prisk*100,Crisk*100
7000  IF (ABS(Prisk-Alpha)<=Atol) AND (ABS(Crisk-Beta)<=Btol) THEN PRINT USING 6
240
7010  IF (ABS(Prisk-Alpha)<=Atol) AND (ABS(Crisk-Beta)<=Btol) THEN Print=Print+1
7020  IF Crisk<Beta-Btol+.004 THEN 7040
7030  NEXT S
7040  DISP
7050  DISP "        WHILE HOLDING ALPHA TO WITHIN ";Atol*100;"% OF THE SPECI
FICATION,      "
7060  DISP "DO YOU WANT TO EXAMINE PLANS WITH AN ACCEPTANCE NUMBER EQUAL TO";C+1
7070  DISP
7080  BEEP
7090  INPUT R$
7100  IF R$="NO" THEN 7120
7110  NEXT C
7120  REM ***** HOLDING BETA  *****
7130  C=0
7140  BEEP
7150  Sample=1
7160  Pap=1/EXP(Sample*Ltpd)
7170  Ck=Pap
7180  Ck2=Beta-Btol
7190  IF Ck2<=0 THEN Ck2=.005
7200  IF Ck<Ck2 THEN 7240
7210  Sample=Sample+1
7220  IF Sample>Maxn THEN 7420
7230  GOTO 7160
7240  IF Sample<10 THEN Low=C+1
7250  IF Sample>=10 THEN Low=Sample-10
7260  IF Sample>Maxn THEN 7420
7270  FOR S=Low TO Sample+10
7280  IF S>Maxn THEN 7420
7290  P=Ltpd
7300  X=0
7310  GOSUB 2600
7320  Crisk=Prob
7330  P=Aql
7340  X=0
7350   GOSUB 2600
7360  Prisk=1-Prob
7370  IF (ABS(Prisk-Alpha)<=Atol) AND (ABS(Crisk-Beta)<=Btol) THEN PRINT USING 6
270;S,C,Prisk*100,Crisk*100
7380  IF (ABS(Prisk-Alpha)<=Atol) AND (ABS(Crisk-Beta)<=Btol) THEN PRINT USING 6
240
7390  IF (ABS(Prisk-Alpha)<=Atol) AND (ABS(Crisk-Beta)<=Btol) THEN Print=Print+1
7400 IF Prisk>Alpha+Atol+.004 THEN 7420
7410  NEXT S
7420  FOR C=1 TO 50
7430  BEEP
7440  Sample=C+1
7450  IF Sample>Maxn THEN 7900
7460  Pap=1/EXP(Sample*Ltpd)
7470  Cum=Pap
7480  FOR Pass=1 TO C
7490  Pap=Pap*Sample*Ltpd/Pass
7500  Cum=Cum+Pap
7510  IF Cum>1 THEN Cum=1
7520  NEXT Pass
7530  Crisk=Cum
7540  Ck=Crisk
7550  IF Ck<Ck2 THEN 7590
7560  Sample=Sample+1
7570  IF Sample>Maxn THEN 7900
7580   GOTO 7460
7590  IF Sample<25 THEN Low=C+1
7600  IF Sample>25 THEN Low=Sample-25
7610  FOR S=Low TO Sample+1000
7620  IF S>Maxn THEN 7830
7630  P=Ltpd
7640  FOR X=0 TO C
```

```
7650   GOSUB 2680
7660  IF X=0 THEN Crisk=Prob
7670  IF X<>0 THEN Crisk=Prob+Crisk
7680  IF Crisk>1 THEN Crisk=1
7690  NEXT X
7700  P=Aql
7710  FOR X=0 TO C
7720   GOSUB 2680
7730  IF X=0 THEN Prisk=Prob
7740  IF X<>0 THEN Prisk=Prob+Prisk
7750  IF Prisk>1 THEN Prisk=1
7760  NEXT X
7770  Prisk=1-Prisk
7780  IF (ABS(Prisk-Alpha)<=Atol) AND (ABS(Crisk-Beta)<=Btol) THEN PRINT USING 6
270;S,C,Prisk*100,Crisk*100
7790  IF (ABS(Prisk-Alpha)<=Atol) AND (ABS(Crisk-Beta)<=Btol) THEN PRINT USING 6
240
7800  IF (ABS(Prisk-Alpha)<=Atol) AND (ABS(Crisk-Beta)<=Btol) THEN Print=Print+1
7810 IF Prisk>Alpha+Atol+.004 THEN 7830
7820  NEXT S
7830  DISP
7840  DISP "        WHILE HOLDING BETA TO WITHIN ";Btol*100;"% OF THE SPECIFI
CATION,      "
7850  DISP "DO YOU WANT TO EXAMINE PLANS WITH AN ACCEPTANCE NUMBER EQUAL TO";C+1
7860  DISP
7870  BEEP
7880  INPUT R$
7890  IF R$="NO" THEN 7910
7900  NEXT C
7910  IF Print=0 THEN PRINT LIN(2);"No plans were found that satisfied the state
d design tolerances.";LIN(4)
7920  IF Print=0 THEN DISP
7930  IF Print=0 THEN DISP "YOU CAN LOOSEN THE TOLERANCES ON ALPHA & BETA AND TR
Y AGAIN, IF YOU WANT TO!"
7940  IF Print=0 THEN DISP
7950  BEEP
7960  FOR I=1 TO 5
7660  IF X=0 THEN Crisk=Prob
7670  IF X<>0 THEN Crisk=Prob+Crisk
7680  IF Crisk>1 THEN Crisk=1
7690  NEXT X
7700  P=Aql
7710  FOR X=0 TO C
7720   GOSUB 2680
7730  IF X=0 THEN Prisk=Prob
7740  IF X<>0 THEN Prisk=Prob+Prisk
7750  IF Prisk>1 THEN Prisk=1
7760  NEXT X
7770  Prisk=1-Prisk
7780  IF (ABS(Prisk-Alpha)<=Atol) AND (ABS(Crisk-Beta)<=Btol) THEN PRINT USING 6
270;S,C,Prisk*100,Crisk*100
7790  IF (ABS(Prisk-Alpha)<=Atol) AND (ABS(Crisk-Beta)<=Btol) THEN PRINT USING 6
240
7800  IF (ABS(Prisk-Alpha)<=Atol) AND (ABS(Crisk-Beta)<=Btol) THEN Print=Print+1
7810 IF Prisk>Alpha+Atol+.004 THEN 7830
7820  NEXT S
7830  DISP
7840  DISP "        WHILE HOLDING BETA TO WITHIN ";Btol*100;"% OF THE SPECIFI
CATION,      "
7850  DISP "DO YOU WANT TO EXAMINE PLANS WITH AN ACCEPTANCE NUMBER EQUAL TO";C+1
7860  DISP
7870  BEEP
7880  INPUT R$
7890  IF R$="NO" THEN 7910
7900  NEXT C
7910  IF Print=0 THEN PRINT LIN(2);"No plans were found that satisfied the state
d design tolerances.";LIN(4)
7920  IF Print=0 THEN DISP
7930  IF Print=0 THEN DISP "YOU CAN LOOSEN THE TOLERANCES ON ALPHA & BETA AND TR
Y AGAIN, IF YOU WANT TO!"
7940  IF Print=0 THEN DISP
7950  BEEP
7960  FOR I=1 TO 5
7970  WAIT 200-I*20
7980  BEEP
7990  NEXT I
8000  GOTO 2010
```

```
0010  IF Sc<>5 THEN 2010
0020  FOR I=1 TO 6
0030  IF I=1 THEN DISP "      ENTER THE ACCEPTABLE QUALITY LEVEL   "
0040  IF I=2 THEN DISP "    ENTER THE LOT TOLERANCE PERCENT DEFECTIVE "
0050  IF I=3 THEN DISP "    ENTER THE PRODUCER'S RISK    "
0060  IF I=4 THEN DISP "    ENTER THE CONSUMER'S RISK    "
0070  IF I=5 THEN DISP "    ENTER THE PRODUCER'S RISK TOLERANCE LIMIT  "
0080  IF I=6 THEN DISP "    ENTER THE CONSUMER'S RISK TOLERANCE LIMIT  "
0090  DISP "     THE ENTRY MUST BE STATED AS A PERCENT!    "
0100  DISP
0110  BEEP
0120  IF I=1 THEN INPUT Aql
0130  IF I=2 THEN INPUT Ltpd
0140  IF I=3 THEN INPUT Alpha
0150  IF I=4 THEN INPUT Beta
0160  IF I=5 THEN INPUT Atol
0170  IF I=6 THEN INPUT Btol
0180  NEXT I
0190  Aql=Aql/100
0200  Ltpd=Ltpd/100
0210  DISP
0220  Maxsam=1000000
0230  DISP "                IS THERE A CONSTRAINT ON THE MAXIMUM SAMPLE SIZE?"
0240 DISP
0250  BEEP
0260  INPUT Ress
0270  IF Ress="NO" THEN 0320
0280  DISP "  Enter the maximum Sample Size "
0290  DISP
0300  BEEP
0310  INPUT Maxsam
0320  DISP
0330  DISP "   IS THERE A FINITE LOT SIZE?    "
0340  DISP
0350  BEEP
0360  INPUT Ress
0370  IF Ress="NO" THEN Dists="BINOMIAL"
0380  IF Ress="NO" THEN 0460
0390  DISP
0400  DISP "     ENTER THE NUMBER OF UNITS COMPRISING THE FINITE LOT SIZE
"
0410  DISP
0420  BEEP
0430  INPUT Lsize
0440  IF Maxsam>Lsize THEN Maxsam=Lsize
0450  Dists="HYPER"
0460  Print=0
0470  FOR I=1 TO 15
0480  FOR J=1 TO 17
0490  IF S105c(I)>=S105s(J) THEN 9350
0500  IF S105s(J)>Maxsam THEN 9360
0510  IF Dists="HYPER" THEN 0690
0520  S=S105s(J)
0530  C=S105c(I)
0540  P=Aql
0550  FOR X=0 TO C
0560  GOSUB 2600
0570  IF X=0 THEN Pa(1,1)=Prob
0580  IF X<>0 THEN Pa(1,1)=Pa(1,1)+Prob
0590  NEXT X
0600  P=Ltpd
0610  FOR X=0 TO C
0620  GOSUB 2600
0630  IF X=0 THEN Pa(2,1)=Prob
0640  IF X<>0 THEN Pa(2,1)=Pa(2,1)+Prob
0650  NEXT X
0660  Riskp=(1-Pa(1,1))*100
0670  Riskc=Pa(2,1)*100
0680  GOTO 9050
0690  N=Lsize
0700  M=S105s(J)
0710  C=S105c(I)
0720  K=Aql*Lsize
0730  IF K=INT(K) THEN 0820
0740  DISP
```

```
8750  DISP "The product of AQL and Lot Size is equal to ";K;". This is the n
umber of "
8760  DISP "defectives er lot which must be an integer, so enter the number of d
efectives"
8770  DISP "per lot that corresponds to AQL!"
8780  DISP
8790  BEEP
8800  INPUT K
8810  GOTO 8730
8820  FOR X=0 TO C
8830  GOSUB 3400
8840  IF X=0 THEN Pa(1,1)=Prob
8850  IF X<>0 THEN Pa(1,1)=Pa(1,1)+Prob
8860  REM
8870  NEXT X
8880  K=Ltpd*Lsize
8890  IF K=INT(K) THEN 8980
8900  DISP
8910  DISP "The product of LTPD and Lot Size is equal to ";K;". This is the
number of "
8920  DISP "defectives er lot which must be an integer, so enter the number of d
efectives"
8930  DISP "per lot that corresponds to LTPD!"
8940  DISP
8950  BEEP
8960  INPUT K
8970  GOTO 8890
8980  FOR X=0 TO C
8990  GOSUB 3400
9000  IF X=0 THEN Pa(2,1)=Prob
9010  IF X<>0 THEN Pa(2,1)=Pa(2,1)+Prob
9020  REM
9030  NEXT X
9040  GOTO 8660
9050  IMAGE 5X,"Optional Single Sampling Plans Via MIL-STD-105D"
9060  BEEP
9070  IMAGE 8X,"________________________________________"
9080  IMAGE 8X,"|Sample|Acceptance|Producer's|Consumer's|"
9090  IMAGE +,8X,"| Size |  Number  |   Risk   |   Risk   |"
9100  IMAGE 10X,"For AQL = ",3D.2D,"% & LTPD = ",3D.2D,"%"
9110  IMAGE 8X,"That meet Producer's Risk =",3D.2D,"±",3D.2D,"%"
9120  IMAGE 8X,"And meet Consumer's Risk =",3D.2D,"±",3D.2D,"%"
9130  IF (ABS(Riskp-Alpha)<=Atol) AND (ABS(Riskc-Beta)<=Btol) THEN 9150
9140  GOTO 9350
9150  IF Print<>0 THEN 9320
9160  PRINT LIN(4)
9170  PRINT USING 9050
9180  PRINT USING 9100;Aql*100,Ltpd*100
9190  PRINT USING 9110;Alpha,Atol
9200  PRINT USING 9120;Beta,Btol
9210  IF Dist$="BINOMIAL" THEN 9250
9220  PRINT SPA(24);"Lot Size = ";Lsize
9230  PRINT SPA(15);"*Hypergeometric Probabilities*"
9240  GOTO 9260
9250  PRINT SPA(10);"****Binomial Probabilities****"
9260  IF Maxsam<1000000 THEN PRINT SPA(8);"Maximum Sample Size Constraint:";Maxs
am
9270  Print=5
9280  PRINT USING 9070
9290  PRINT USING 9080
9300  PRINT USING 9090
9310  PRINT USING 9070
9320  IMAGE +,8X,"|",5D," |"2X,6D,2X,"|",6D.2D,"%|",6D.2D,"%|"
9330  PRINT USING 9320;S105s(J),S105c(I),Riskp,Riskc
9340  PRINT USING 9070
9350  NEXT J
9360  NEXT I
9370  IF Print<>0 THEN PRINT LIN(1);"A complete OC Curve for any of these plans
 can be obtained by exercising";LIN(1);"Option 1 of this program segment."
9380  IF Print=0 THEN PRINT LIN(6);"No Plans, simultaneously meeting the design
tolerances on Producer's and"
```

```
9400  IF Print=0 THEN PRINT "re-running this option will increase your chances o
f obtaining optional plans."
9410  GOTO 2010
```

APPENDIX C
DOUBLE SAMPLING DESIGN AND ASSESSMENT SOURCE CODE

APPENDIX C
DOUBLE SAMPLING DESIGN AND ASSESSMENT SOURCE CODE

```
2000  REM           **** DOUBLE SAMPLE DESIGN AND/OR RISK ASSESSMENT ****
2010  DISP "                                                              "
2020  DISP "            > Double Sampling Plan Option Menu <
"
2030  DISP "  Option Description                              Select Code
"
2040  DISP " >Double Sample Operating Characteristic
"
2050  DISP "  Curve Construction And Risk Assessment..............1
"
2060  DISP " >Double Sampling Plan Derivation, Via Poisson
"
2070  DISP "  Approximation of ALPHA = 5% AND Beta = 10% for
"
2080  DISP "  Given Specifications of AQL & LTPD..................2
"
2090  DISP " >Double Sampling Plan Derivation from MIL-STD-105D
"
2100  DISP "  Acceptance/Rejection Numbers and all Stated Sample
"
2110  DISP "  Sizes. This option provides a Binomial or Hyper-
"
2120  DISP "  geometric Assessment of Alpha and Beta for Stated
"
2130  DISP "  AQL & LTPD values. The assessments are limited to
"
2140  DISP "  the feasible combinations of sample size and accept
"
2150  DISP "  reject numbers specified in MIL-STD-105D............3
"
2160  DISP " >EXIT this Selected Option...........................4
"
2170  DISP "                                                              "
2180  DISP "ENTER THE SELECT CODE OF THE DESIRED OPTION."
2190  DISP
2200  BEEP
2210  INPUT Sc
2220  IF Sc=4 THEN RETURN
2230  IF Sc<>1 THEN 7140
2240  FOR I=1 TO 6
2250  IF I=1 THEN DISP "  Enter the First Sample's Size...."
2260  IF I=2 THEN DISP "  Enter the Second Sample's Size...."
2270  IF I=3 THEN DISP "  Enter the First Sample's Acceptance Number...."
2280  IF I=4 THEN DISP "  Enter the Second Sample's Acceptance Number...."
2290  IF I=5 THEN DISP "  Enter the First Sample's Rejection Number...."
2300  IF I=6 THEN DISP "  Enter the Second Sample's Rejection Number...."
2310  DISP
2320  BEEP
2330  IF I=1 THEN INPUT Dss1
2340  IF I=2 THEN INPUT Dss2
2350  IF I=3 THEN INPUT Dap1
2360  IF I=4 THEN INPUT Dap2
2370  IF I=5 THEN INPUT Dre1
2380  IF I=6 THEN INPUT Dre2
2390  NEXT I
2400  Sample=Dss1+Dss2
2410  DISP "                 DO YOU HAVE A FINITE LOT SIZE?"
2420  DISP
2430  BEEP
2440  INPUT Res$
2450  IF Res$="NO" THEN Dist$="BINOMIAL"
2460  IF Res$="NO" THEN 2620
2470  DISP "    ENTER THE FINITE LOT SIZE "
2480  DISP
2490  BEEP
2500  INPUT Lsize
2510  Ratio=Sample/Lsize
2520  IF Ratio>=.1 THEN Dist$="HYPER"
2530  IF Ratio>=.1 THEN 4020
2540  DISP "Since the ratio of total possible sample size to lot size is less th
an 10%,"
2550  DISP "it maybe acceptable to use a Binomial Approximation to the Hypergeom
etric."
2560  DISP "DO YOU WISH TO USE THIS APPROXIMATION?"
2570  DISP
2580  BEEP
```

```
2590  INPUT Res$
2600  IF Re$="NO" THEN Dist$="HYPER"
2610  IF Re$="YES" THEN Dist$="BINOMIAL"
2620  IF Dist$="HYPER" THEN 4020
2630  IF Dist$="BINOMIAL" THEN 3100
2640  REM BINOMIAL SUBROUTINE
2650  IF (S-X<0) OR (X<0) THEN Prob=0
2660  IF (S-X<0) OR (X<0) THEN RETURN
2670  IF (S-X=0) OR (X=0) THEN Prob=P^X*(1-P)^(S-X)
2680  IF (S-X=0) OR (X=0) THEN RETURN
2690  Prob=1
2700  FOR Is=1 TO X
2710  Prob=Prob*P
2720  NEXT Is
2730  FOR Is=1 TO S-X
2740  Prob=Prob*((X+Is)/Is)*(1-P)
2750  NEXT Is
2760  RETURN
2770  REM HYPERGEOMETRIC DISTRIBUTION
2780  IF X<0 THEN Prob=0
2790  IF X<0 THEN RETURN
2800  IF X>K THEN Prob=0
2810  IF X>K THEN RETURN
2820  IF X>M THEN Prob=0
2830  IF X>M THEN RETURN
2840  Prob=1
2850  F(1)=K
2860  F(2)=N-K
2870  F(3)=M
2880  F(4)=N-M
2890  F(5)=X
2900  F(6)=K-X
2910  F(7)=M-X
2920  F(8)=N-K-M+X
2930  F(9)=N
2940  FOR Is=1 TO 9
2950  IF F(Is)<1 THEN F(Is)=1
2960  NEXT Is
2970  Prob=Prob*F(1)*F(2)*F(3)*F(4)/(F(5)*F(6)*F(7)*F(8)*F(9))
2980  FOR Is=1 TO 9
2990  F(Is)=F(Is)-1
3000  IF F(Is)<1 THEN F(Is)=1
3010  NEXT Is
3020  Ck=0
3030  FOR Is=1 TO 9
3040  IF F(Is)=1 THEN 3060
3050  Ck=1
3060  NEXT Is
3070  IF Ck=0 THEN RETURN
3080  GOTO 2970
3090  RETURN
3100  REM BINOMIAL EVALUATION
3110  P=.01
3120  S=Dss1
3130  C=Dap1
3140  FOR X=0 TO C
3150  GOSUB 2640
3160  IF X=0 THEN Pa(1,1)=Prob
3170  IF X<>0 THEN Pa(1,1)=Prob+Pa(1,1)
3180  NEXT X
3190  Cont(1)=0
3200  FOR X=C+1 TO Dre1-1
3210  Con(X)=X
3220  GOSUB 2640
3230  Conp(X)=Prob
3240  Cont(1)=Cont(1)+Conp(X)
3250  NEXT X
3260  Asn(1)=Dss1+Cont(1)*Dss2
3270  S=Dss2
3280  Pa(2,1)=0
3290  FOR I=C+1 TO Dre2-1
3300  FOR X=0 TO Dre2-1-Con(I)
3310  GOSUB 2640
```

```
3320  Pa(2,1)=Pa(2,1)+Conp(I)*Prob
3330  NEXT X
3340  NEXT I
3350  Pa(3,1)=Pa(1,1)+Pa(2,1)
3360  Pr(1,1)=1-Pa(1,1)-Cont(1)
3370  Pr(2,1)=1-Pa(3,1)
3380  IF Pa(3,1)<.02 THEN 3440
3390  IF (Pa(3,1)<.9) AND (Pa(3,1)>=.25) THEN P=P+.01
3400  IF Pa(3,1)>=.9 THEN P=P+.05
3410  IF Pa(3,1)<.25 THEN P=P+.01
3420  DISP P
3430  GOTO 3120
3440  DISP "The probability of acceptance is";Pa(3,1)*100;"% at percent defectiv
e "
3450  DISP "equal to";P*100;"%."
3460  DISP "   WHAT RANGE DO YOU WANT TO INCLUDE ON THE OC CURVE'S PERCENT DEFE
CTIVE AXIS? "
3470  DISP "   The entry must be stated as a percent(i.e., fifty percent is 50
).    "
3480  DISP
3490  BEEP
3500  INPUT Maxx
3510  Maxx=Maxx+1
3520  DISP "ENTER THE DESIRED LABELING INTERVAL ON THE PERCENT DEFECTIVE AXIS."
3530  DISP "   The entry must be stated as a percent(i.e., one percent is 1).
 "
3540  DISP
3550  BEEP
3560  INPUT Xint
3570  Inc=Maxx/100
3580  FOR I=1 TO 100
3590  Pd(I)=I*Inc
3600  DISP
3610  DISP Pd(I)
3620  P=Pd(I)/100
3630  S=Dss1
3640  C=Dap1
3650  FOR X=0 TO C
3660  GOSUB 2640
3670  IF X=0 THEN Pa(1,I)=Prob
3680  IF X<>0 THEN Pa(1,I)=Prob+Pa(1,I)
3690  NEXT X
3700  Cont(I)=0
3710  FOR X=C+1 TO Dre1-1
3720  Con(X)=X
3730  GOSUB 2640
3740  Conp(X)=Prob
3750  Cont(I)=Cont(I)+Conp(X)
3760  NEXT X
3770  Asn(I)=Dss1+Cont(I)*Dss2
3780  S=Dss2
3790  Pa(2,I)=0
3800  FOR J=C+1 TO Dre2-1
3810  FOR X=0 TO Dre2-1-Con(J)
3820  GOSUB 2640
3830  Pa(2,I)=Pa(2,I)+Conp(J)*Prob
3840  NEXT X
3850  NEXT J
3860  Pa(3,I)=Pa(1,I)+Pa(2,I)
3870  Pr(1,I)=1-Pa(1,I)-Cont(I)
3880  Pr(2,I)=1-Pa(3,I)
3890  NEXT I
3900  Lim=100
3910  GOSUB 4510
3920  DISP "DO YOU WANT ANY SPECIFIC POINTS PRINTED?"
3930  DISP
3940  BEEP
3950  INPUT Res
3960  IF Res="NO" THEN 2010
3970  PRINT LIN(4);SPA(10);"Risk Evaluation For the Double Sampling Plan"
3980  PRINT SPA(10);"First Sample:  n = ";Dss1;" Accept on ";Dap1;", Reject on "
;Dre1
3990  PRINT SPA(10);"Second Sample: n = ";Dss2;" Accept on ";Dap2;", Reject on "
;Dre2
4000  PRINT SPA(17);"(Binomial Distribution Probabilities)";LIN(1)
4010  PRINT USING 4060
4020  PRINT USING 4070
```

```
4030  PRINT USING 4080
4040  PRINT USING 4090
4050  PRINT USING 4100
4060  IMAGE "_______________________________________________________________
_______"
4070  IMAGE "__________|__________First Sample Risks__________|_____ . Plan Risks
____|Average|"
4080  IMAGE "| Percent |Acceptance |Continue   | Rejection |Acceptance | Rejecti
on |Sample |"
4090  IMAGE +,"|Defective|Probability|Probability|Probability|Probability|Probab
ility|Number |"
4100  IMAGE "______________________________________________________________
_______"
4110  IMAGE +,"|",4D.4D,"|",5(6D.4D,"|"),4D.2D,"|"
4120  DISP "ENTER THE PERCENT DEFECTIVE....."
4130  DISP
4140  BEEP
4150  INPUT P
4160  P=P/100
4170  S=Dss1
4180  C=Dap1
4190  FOR X=0 TO C
4200  GOSUB 2640
4210  IF X=0 THEN Pa(1,1)=Prob
4220  IF X<>0 THEN Pa(1,1)=Prob+Pa(1,1)
4230  NEXT X
4240  Cont(1)=0
4250  FOR X=C+1 TO Dre1-1
4260  Con(X)=X
4270  GOSUB 2640
4280  Conp(X)=Prob
4290  Cont(1)=Cont(1)+Conp(X)
4300  NEXT X
4310  Asn(1)=Dss1+Cont(1)*Dss2
4320  S=Dss2
4330  Pa(2,1)=0
4340  FOR J=C+1 TO Dre2-1
4350  FOR X=0 TO Dre2-1-Con(J)
4360  GOSUB 2640
4370  Pa(2,1)=Pa(2,1)+Conp(J)*Prob
4380  NEXT X
4390  NEXT J
4400  Pa(3,1)=Pa(1,1)+Pa(2,1)
4410  Pr(1,1)=1-Pa(1,1)-Cont(1)
4420  Pr(2,1)=1-Pa(3,1)
4430  PRINT USING 4110;P*100,Pa(1,1)*100,Cont(1)*100,Pr(1,1)*100,Pa(3,1)*100,Pr(
2,1)*100,Asn(1)
4440  PRINT USING 4100
4450  DISP "    DO YOU WANT ANYMORE?   "
4460  DISP
4470  BEEP
4480  INPUT Res
4490  IF Res="NO" THEN 2010
4500  GOTO 4120
4510  REM OC CURVE
4520  PLOTTER IS "9872A"
4530  PLOTTER 7,5 IS ON
4540  LOCATE 10,100,10,100
4550  SCALE 0,Maxx,0,104
4560  CSIZE 2
4570  LAXES Xint,5,0,0,-1,1
4580  MOVE 5*Xint,101
4590  LABEL "       Operating Characteristic Curve"
4600  LABEL "First Sample:  n=";Dss1;": C1=";Dap1;"  R1=";Dre1
4610  LABEL "Second Sample: n=";Dss2;": C2=";Dap2;"  R2=";Dre2
4620  LABEL "          Binomial Probabilities"
4630  MOVE 0,100
4640  FOR Pass=1 TO 2
4650  MOVE 0,100
4660  IF Pass=1 THEN PEN 2
4670  IF Pass=2 THEN PEN 3
4680  IF Pass=1 THEN Q=1
4690  IF Pass=2 THEN Q=3
4700  FOR I=1 TO Lim
4710  DRAW Pd(I),Pa(Q,1)*100
4720  NEXT I
```

```
4730  NEXT Pass
4740  PEN 1
4750  MOVE 5*Xint,-5
4760  LABEL "PERCENT DEFECTIVE"
4770  MOVE Xint/4,101
4780  LABEL "Pa(%)"
4790  MOVE 120,120
4800  GOSUB 6790
4810  RETURN
4820  REM HYPERGEOMETRIC EVALUATION
4830  K=Dap2
4840  N=Lsize
4850  M=Dss1
4860  Bad=K
4870  C=Dap1
4880  FOR X=0 TO C
4890  GOSUB 2770
4900  IF X=0 THEN Pa(1,1)=Prob
4910  IF X<>0 THEN Pa(1,1)=Prob+Pa(1,1)
4920  NEXT X
4930  Cont(1)=0
4940  FOR X=C+1 TO Dre1-1
4950  Con(X)=X
4960  GOSUB 2770
4970  Conp(X)=Prob
4980  Cont(1)=Cont(1)+Conp(X)
4990  NEXT X
5000  Asn(1)=Dss1+Cont(1)*Dss2
5010  M=Dss2
5020  N=Lsize-Dss1
5030  Pa(2,1)=0
5040  FOR I=C+1 TO Dre2-1
5050  K=Bad-I
5060  FOR X=0 TO Dre2-1-Con(I)
5070  GOSUB 2770
5080  Pa(2,1)=Pa(2,1)+Conp(I)*Prob
5090  NEXT X
5100  NEXT I
5110  K=Bad
5120  Pa(3,1)=Pa(1,1)+Pa(2,1)
5130  Pr(1,1)=1-Pa(1,1)-Cont(1)
5140  Pr(2,1)=1-Pa(3,1)
5150  DISP "For ";K;" defectives per lot, the Pa for the plan is";Pa(3,1)
5160  DISP
5170  IF Pa(3,1)<.02 THEN 5210
5180  IF Pa(3,1)>=.1 THEN K=K+5
5190  IF Pa(3,1)<.1 THEN K=K+1
5200  GOTO 4850
5210  DISP
5220  DISP "The probability of acceptance is";Pa(3,1)*100;"% at";K;" defectives
per Lot."
5230  DISP
5240  DISP " WHAT RANGE DO YOU WANT TO INCLUDE ON THE OC CURVE'S DEFECTIVES PER
 LOT AXIS? "
5250  DISP "   The entry must be stated as an integer.        "
5260  DISP
5270  BEEP
5280  INPUT Maxx
5290  Maxx=Maxx+1
5300  DISP
5310  DISP "ENTER THE DESIRED LABELING INTERVAL ON THE DEFECTIVES PER LOT AXIS."
5320  DISP "   The entry must be stated as an integer.        "
5330  DISP
5340  BEEP
5350  INPUT Xint
5360  IF Maxx<=100 THEN Lim=Maxx
5370  IF Maxx>100 THEN Lim=100
5380  IF Maxx<=100 THEN Inc=1
5390  IF (Maxx<=200) AND (Maxx>100) THEN Inc=2
5400  IF (Maxx<=400) AND (Maxx>200) THEN Inc=4
5410  IF (Maxx<=500) AND (Maxx>400) THEN Inc=5
5420  IF (Maxx<=600) AND (Maxx>500) THEN Inc=6
5430  IF (Maxx<=1000) AND (Maxx>600) THEN Inc=10
5440  FOR I=1 TO Lim
5450  Pd(I)=Dap2+(I-1)*Inc
5460  DISP
```

```
5470  DISP Pd(I)
5480  K=Pd(I)
5490  Bad=K
5500  N=Lsize
5510  M=Dss1
5520  C=Dap1
5530  FOR X=0 TO C
5540  GOSUB 2770
5550  IF X=0 THEN Pa(1,I)=Prob
5560  IF X<>0 THEN Pa(1,I)=Prob+Pa(1,I)
5570  NEXT X
5580  Cont(I)=0
5590  FOR X=C+1 TO Dre1-1
5600  Con(X)=X
5610  GOSUB 2770
5620  Conp(X)=Prob
5630  Cont(I)=Cont(I)+Conp(X)
5640  NEXT X
5650  Asn(I)=Dss1+Cont(I)*Dss2
5660  M=Dss2
5670  N=Lsize-Dss1
5680  Pa(2,I)=0
5690  FOR J=C+1 TO Dre2-1
5700  K=Bad-J
5710  FOR X=0 TO Dre2-1-Con(J)
5720  GOSUB 2770
5730  Pa(2,I)=Pa(2,I)+Conp(J)*Prob
5740  NEXT X
5750  NEXT J
5760  Pa(3,I)=Pa(1,I)+Pa(2,I)
5770  Pr(1,I)=1-Pa(1,I)-Cont(I)
5780  Pr(2,I)=1-Pa(3,I)
5790  BEEP
5800  DISP "K=";Pd(I);"  Pa[1st]=";Pa(1,I);"  Pa(Plan)=";Pa(3,I)
5810  NEXT I
5820  GOSUB 6460
5830  DISP "DO YOU WANT ANY SPECIFIC POINTS PRINTED?"
5840  DISP
5850  BEEP
5860  INPUT Res
5870  IF Res="NO" THEN 2010
5880  PRINT LIN(4);SPA(10);"Risk Evaluation For the Double Sampling Plan"
5890  PRINT SPA(10);"First Sample:  n = ";Dss1;" Accept on ";Dap1;", Reject on "
;Dre1
5900  PRINT SPA(10);"Second Sample: n = ";Dss2;" Accept on ";Dap2;", Reject on "
;Dre2;LIN(1);SPA(25);"Lot Size = ";Lsize
5910  PRINT SPA(17);"(Hypergeometric Distribution Probabilities)";LIN(1)
5920  PRINT USING 5970
5930  PRINT USING 5980
5940  PRINT USING 5990
5950  PRINT USING 6000
5960  PRINT USING 6010
5970  IMAGE "________________________________________________________________
________"
5980  IMAGE "__________|          First Sample Risks          |          Plan Risks
____|Average|"
5990  IMAGE "|Defective|Acceptance |Continue    | Rejection |Acceptance | Rejecti
on |Sample |"
6000  IMAGE +,"| Per Lot |Probability|Probability|Probability|Probability|Probab
ility|Number |"
6010  IMAGE "________________________________________________________________
________"
6020  IMAGE +,"|",2X,5D,2X,"|",5(6D.4D,"|"),4D.2D,"|"
6030  DISP "ENTER THE NUMBER OF DEFECTIVES PER LOT...."
6040  DISP
6050  BEEP
6060  INPUT K
6070  M=Dss1
6080  N=Lsize
6090  C=Dap1
6100  Bad=K
6110  FOR X=0 TO C
6120  GOSUB 2770
6130  IF X=0 THEN Pa(1,I)=Prob
6140  IF X<>0 THEN Pa(1,I)=Prob+Pa(1,I)
6150  NEXT X
6160  Cont(I)=0
```

```
6170  FOR X=C+1 TO Dre1-1
6180  Con(X)=X
6190  GOSUB 2770
6200  Conp(X)=Prob
6210  Cont(1)=Cont(1)+Conp(X)
6220  NEXT X
6230  Asn(1)=Dss1+Cont(1)*Dss2
6240  N=Lsize-Dss1
6250  M=Dss2
6260  Pa(2,1)=0
6270  FOR J=C+1 TO Dre
6280  K=Bad-J
6290  FOR X=0 TO Dre2-1-Con(J)
6300  GOSUB 2770
6310  Pa(2,1)=Pa(2,1)+Conp(J)*Prob
6320  NEXT X
6330  NEXT J
6340  K=Bad
6350  Pa(3,1)=Pa(1,1)+Pa(2,1)
6360  Pr(1,1)=1-Pa(1,1)-Cont(1)
6370  Pr(2,1)=1-Pa(3,1)
6380  PRINT USING 6020;K,Pa(1,1)*100,Cont(1)*100,Pr(1,1)*100,Pa(3,1)*100,Pr(2,1)
*100,Asn(1)
6390  PRINT USING 6010
6400  DISP "    DO YOU WANT ANYMORE?   "
6410  DISP
6420  BEEP
6430  INPUT Res
6440  IF Res="NO" THEN 2010
6450  GOTO 6030
6460  REM OC CURVE
6470  PLOTTER IS "9872A"
6480  PLOTTER 7,5 IS ON
6490  LOCATE 10,100,10,100
6500  SCALE 0,Maxx,0,104
6510  CSIZE 2
6520  LAXES Xint,5,0,0,-1,1
6530  MOVE 5*Xint,101
6540  LABEL "       Operating Characteristic Curve"
6550  LABEL "First Sample:  n=";Dss1;": C1=";Dap1;"  R1=";Dre1
6560  LABEL "Second Sample: n=";Dss2;": C2=";Dap2;"  R2=";Dre2
6570  LABEL "              Lot Size = ";Lsize
6580  LABEL "        Hypergeometric Probabilities"
6590  MOVE 0,100
6600  FOR Pass=1 TO 2
6610  MOVE 0,100
6620  IF Pass=1 THEN PEN 2
6630  IF Pass=2 THEN PEN 3
6640  IF Pass=1 THEN Q=1
6650  IF Pass=2 THEN Q=3
6660  FOR I=1 TO Lim
6670  DRAW Pd(I),Pa(Q,I)*100
6680  NEXT I
6690  NEXT Pass
6700  PEN 1
6710  MOVE 5*Xint,-5
6720  LABEL "DEFECTIVES PER LOT"
6730  MOVE Xint/4,101
6740  LABEL "Pa(%)"
6750  MOVE 120,120
6760  GOSUB 6790
6770  REM
6780  RETURN
6790  DISP
6800  DISP "         RELOAD THE PLOTTER. WHEN DONE, ENTER GO!    "
6810  DISP
6820  BEEP
6830  INPUT R$
6840  PLOTTER IS "9872A"
6850  PLOTTER 7,5 IS ON
6860  Big=-10
6870  FOR I=1 TO Lim
6880  IF Asn(I)>Big THEN Big=Asn(I)
6890  NEXT I
6900  Maxy=INT(Big)+3
6910  LOCATE 10,100,10,100
6920  SCALE 0,Maxx,0,Maxy+3
```

```
6930  CSIZE 2
6940  Yint=INT(Maxy/20)
6950  IF Yint<1 THEN Yint=1
6960  LAXES Xint,Yint,0,0,-1,1
6970  MOVE 5*Xint,Maxy
6980  LABEL "        Average Sample Number Curve"
6990  LABEL "First Sample:  n=";Dss1;": C1=";Dap1;"  R1=";Dre1
7000  LABEL "Second Sample: n=";Dss2;": C2=";Dap2;"  R2=";Dre2
7010  IF Distr$="HYPER" THEN LABEL "              Lot Size = ";Lsize
7020  IF Dist$="HYPER" THEN LABEL "        Hypergeometric Probabilities"
7030  IF Dist$<>"HYPER" THEN LABEL "          Binomial Probabilities"
7040  MOVE Xint/5,Maxy
7050  LABEL "ASN"
7060  MOVE 4*Xint,Yint
7070  IF Dist$="BINOMIAL" THEN LABEL "PERCENT DEFECTIVE"
7080  IF Dist$<>"BINOMIAL" THEN LABEL "DEFECTIVES PER LOT"
7090  MOVE 0,Dss1
7100  FOR I=1 TO Lim
7110  DRAW Pd(I),Asn(I)
7120  NEXT I
7130  RETURN
7140  IF Sc<>2 THEN 7850
7150  DISP "The Double Sampling plans addressed herein are of two types. The fir
st type"
7160  DISP "specifies that the second sample's size is twice that of the first w
hile the "
7170  DISP "second type specifies that both samples are of equal size."
7180  DISP
7190  DISP "     IF YOU WANT OPTIONAL PLANS IN WHICH n2 = 2(n1), ENTER A 1.
"
7200  DISP "     IF YOU WANT OPTIONAL PLANS IN WHICH n2 = n1, ENTER A 2.    "
7210  DISP
7220  BEEP
7230  INPUT Sel
7240  FOR I=1 TO 2
7250  IF I=1 THEN DISP " ENTER THE ACCEPTABLE QUALITY LEVEL, STATED IN PERCENT
FORM. "
7260  IF I=2 THEN DISP " ENTER THE LOT TOLERANCE PERCENT DEFECTIVE, STATED IN P
ERCENT FORM. "
7290  DISP
7300  BEEP
7310  IF I=1 THEN INPUT Aql
7320  IF I=2 THEN INPUT Ltpd
7350  NEXT I
7360  Aql=Aql/100
7370  Ltpd=Ltpd/100
7380  Alpha=Alpha/100
7390  Beta=Beta/100
7400  IF Sel=1 THEN Lim=16
7410  IF Sel=2 THEN Lim=17
7420  FOR J=1 TO Lim
7430  Dss1=INT(Ccea(Sel,J,5)/Aql)+1
7440  Pr(1,J)=Dss1
7450  IF Sel=1 THEN Pr(2,J)=2*Dss1
7460  IF Sel=2 THEN Pr(2,J)=Dss1
7470  Pa(1,J)=Aql
7480  Pa(2,J)=Ccea(Sel,J,6)/Dss1
7490  Pa(3,J)=Ccea(Sel,J,7)/Dss1
7500  Pa(4,J)=Ccea(Sel,J,8)*Dss1
7510  Dss1=INT(Ccea(Sel,J,7)/Ltpd)+1
7520  Pr(3,J)=Dss1
7530  IF Sel=1 THEN Pr(4,J)=2*Dss1
7540  IF Sel=2 THEN Pr(4,J)=Dss1
7550  Pa(5,J)=Ccea(Sel,J,5)/Dss1
7560  Pa(6,J)=Ccea(Sel,J,6)/Dss1
7570  Pa(7,J)=Ltpd
7580  Pa(8,J)=Ccea(Sel,J,8)*Dss1
7590  NEXT J
7600  IMAGE "          ______________________________________________________
"
7610  IMAGE "________|Sampling Plan Specification| Percent Defective at  |Aver
age|"
```

```
7620  IMAGE  "| Plan |Sample  Size |Acceptance On|Which the P(Acceptance)|Samp
le |"
7630  IMAGE  "|Option|First |Second|First |Second|is Approximately Equal |Numb
er |"
7640  IMAGE +,"|Number|Sample|Sample|Sample|Sample|  95%  |  50%  |  10%  |Pa=95
% |"
7650  IMAGE "______________________________________________________________________
"
7660  IMAGE +,"|",1X,4D," |",4(6D,"|"),3(2D.4D,"|"),4D.2D,"|"
7670  PRINT USING 7600
7680  PRINT USING 7610
7690  PRINT USING 7620
7700  PRINT USING 7630
7710  PRINT USING 7640
7720  PRINT USING 7650
7730  Count=0
7740  FOR J=1 TO Lim
7750  Count=Count+1
7760  PRINT USING 7660;Count,Pr(1,J),Pr(2,J),Ccea(Del,J,3),Ccea(Sel,J,4),Pa(1,J)
*100,Pa(2,J)*100,Pa(3,J)*100,Pa(4,J)
7770  PRINT USING 7650
7780  Count=Count+1
7790  PRINT USING 7660;Count,Pr(3,J),Pr(4,J),Ccea(Del,J,3),Ccea(Sel,J,4),Pa(5,J)
*100,Pa(6,J)*100,Pa(7,J)*100,Pa(8,J)
7800  PRINT USING 7650
7810  NEXT J
7820  PRINT LIN(2);"Exact risk assessments are available for any selected plan b
y"
7830  PRINT LIN(2);"exercising selection number 1 of the Double Sampling Menu.";
LIN(1)
7840  GOTO 2010
7850  IF Sc<>3 THEN 2010
7860  FOR I=1 TO 6
7870  DISP
7880  IF I=1 THEN DISP " ENTER THE ACCEPTABLE QUALITY LEVEL, STATED AS A PERCEN
T. "
7890  IF I=2 THEN DISP " ENTER THE LOT TOLERANCE PERCENT DEFECTIVE, STATED AS A
 PERCENT. "
7900  IF I=3 THEN DISP " ENTER THE PRODUCER'S RISK, STATED AS A PERCENT. "
7910  IF I=4 THEN DISP " ENTER THE CONSUMER'S RISK, STATED AS A PERCENT. "
7920  IF I=5 THEN DISP " ENTER THE DESIGN TOLERANCE ON PRODUCER'S RISK, STATED
AS A PERCENT. "
7930  IF I=6 THEN DISP " ENTER THE DESIGN TOLERANCE ON CONSUMER'S RISK, STATED
AS A PERCENT. "
7940  DISP
7950  BEEP
7960  IF I=1 THEN INPUT Aql
7970  IF I=2 THEN INPUT Ltpd
7980  IF I=3 THEN INPUT Alpha
7990  IF I=4 THEN INPUT Beta
8000  IF I=5 THEN INPUT Atol
8010  IF I=6 THEN INPUT Btol
8020  NEXT I
8030  Aql=Aql/100
8040  Ltpd=Ltpd/100
8050  DISP
8060  DISP "IS THERE A CONSTRAINT ON THE NUMBER OF UNITS THAT CAN BE SAMPLED?"
8070  DISP
8080  INPUT Res$
8090  IF Res$="NO" THEN Maxsam=1000000
8100  IF Res$="NO" THEN 8160
8110  DISP
8120  DISP "ENTER THE MAXIMUM NUMBER OF UNITS THAT MAY BE SAMPLED."
8130  DISP
8140  BEEP
8150  INPUT Maxsam
8160  DISP "          DO YOU HAVE A FINITE LOT SIZE?"
8170  DISP
8180  BEEP
8190  INPUT Res$
8200  IF Res$="NO" THEN Dist$="BINOMIAL"
8210  IF Res$="YES" THEN Dist$="HYPER"
8220  IF Res$="NO" THEN 8270
8230  DISP "        ENTER THE LOT SIZE."
8240  DISP
8250  BEEP
8260  INPUT Lsize
```

```
8270  Print=0
8280  FOR I=1 TO 16
8290  DISP
8300  DISP I
8310  Check=0
8320  FOR J=1 TO 16
8330  IF 2*Mils(J)>Maxsam THEN 9960
8340  IF Mils(J)<=Milr(I,1) THEN 9950
8350  IF 2*Mils(J)<=Milr(I,2) THEN 9950
8360  DISP TAB(J);J
8370  IF Dist$="HYPER" THEN 8910
8380  P=Aql
8390  S=Mils(J)
8400  C=Mila(I,1)
8410  FOR X=0 TO C
8420  GOSUB 2640
8430  IF X=0 THEN Pa(1,1)=Prob
8440  IF X<>0 THEN Pa(1,1)=Pa(1,1)+Prob
8450  NEXT X
8460  Cont(1)=0
8470  FOR X=C+1 TO Milr(I,1)-1
8480  Con(X)=X
8490   GOSUB 2640
8500  Conp(X)=Prob
8510  Cont(1)=Cont(1)+Conp(X)
8520  NEXT X
8530  Asn(1)=Mils(J)*(1+Cont(1))
8540  Pa(2,1)=0
8550  FOR J1=C+1 TO Milr(I,2)-1
8560  FOR X=0 TO Milr(I,2)-1-Con(J1)
8570  GOSUB 2640
8580  Pa(2,1)=Pa(2,1)+Conp(J1)*Prob
8590  NEXT X
8600  NEXT J1
8610  Pa(3,1)=(Pa(1,1)+Pa(2,1))*100
8620  IF Pa(3,1)>100 THEN Pa(3,1)=100
8630  Pr(2,1)=100-Pa(3,1)
8640  Cont(1)=Cont(1)*100
8650  P=Ltpd
8660  FOR X=0 TO C
8670  GOSUB 2640
8680  IF X=0 THEN Pa(1,2)=Prob
8690  IF X<>0 THEN Pa(1,2)=Pa(1,2)+Prob
8700  NEXT X
8710  Cont(2)=0
8720  FOR X=C+1 TO Milr(I,1)-1
8730  Con(X)=X
8740   GOSUB 2640
8750  Conp(X)=Prob
8760  Cont(2)=Cont(2)+Conp(X)
8770  NEXT X
8780  Asn(2)=Mils(J)*(1+Cont(2))
8790  Pa(2,2)=0
8800  FOR J1=C+1 TO Milr(I,2)-1
8810  FOR X=0 TO Milr(I,2)-1-Con(J1)
8820  GOSUB 2640
8830  Pa(2,2)=Pa(2,2)+Conp(J1)*Prob
8840  NEXT X
8850  NEXT J1
8860  Pa(3,2)=(Pa(1,2)+Pa(2,2))*100
8870  IF Pa(3,2)>100 THEN Pa(3,2)=100
8880  Cont(2)=Cont(2)*100
8890  Pr(2,2)=100-Pa(3,2)
8900  GOTO 9690
8910  K=Aql*Lsize
8920  IF K=INT(K) THEN 9000
8930  DISP
8940  DISP "THE PRODUCT OF ACCEPTABLE QUALITY LEVEL & LOT SIZE IS   ";K
8950  DISP "TO USE THE HYPERGEOMETRIC DISTRIBUTION, THIS PARAMETER MUST BE AN I
NTEGER."
8960  DISP " ENTER THE NUMBER OF DEFECTIVES PER LOT THAT IS CONSIDERED TO BE AC
CEPTABLE. "
8970  DISP
8980  BEEP
8990  INPUT K
9000  N=Lsize
```

```
9010  Bad=K
9020  M=Mils(J)
9030  C=Mila(I,1)
9040  FOR X=0 TO C
9050   GOSUB 2770
9060  IF X=0 THEN Pa(1,1)=Prob
9070  IF X<>0 THEN Pa(1,1)=Pa(1,1)+Prob
9080  NEXT X
9090  Cont(1)=0
9100  FOR X=C+1 TO Milr(I,1)-1
9110  Con(X)=X
9120  GOSUB 2770
9130  Conp(X)=Prob
9140  Cont(1)=Cont(1)+Conp(X)
9150  NEXT X
9160  Asn(1)=Mils(J)*(1+Cont(1))
9170  N=Lsize-Mils(J)
9180  Pa(2,1)=0
9190  FOR It=C+1 TO Milr(I,1)-1
9200  K=Bad-It
9210  FOR X=0 TO Milr(I,2)-1-Con(It)
9220   GOSUB 2770
9230  Pa(2,1)=Pa(2,1)+Conp(It)*Prob
9240  NEXT X
9250  NEXT It
9260  Cont(1)=100*Cont(1)
9270  Pa(3,1)=100*(Pa(1,1)+Pa(2,1))
9280  IF Pa(3,1)>100 THEN Pa(3,1)=100
9290  Pr(2,1)=100-Pa(3,1)
9300  K=Ltpd*Lsize
9310  IF K=INT(K) THEN 9380
9320  DISP "THE PRODUCT OF LOT TOLERANCE PERCENT DEFECTIVE & LOT SIZE IS   ";K
9330  DISP "TO USE THE HYPERGEOMETRIC DISTRIBUTION, THIS PARAMETER MUST BE AN I
NTEGER."
9340  DISP " ENTER THE NUMBER OF DEFECTIVES PER LOT THAT IS CONSIDERED TO BE MA
RGINAL. "
9350  DISP
9360  BEEP
9370  INPUT K
9380  N=Lsize
9390  Bad=K
9400  M=Mils(J)
9410  C=Mila(I,1)
9420  FOR X=0 TO C
9430   GOSUB 2770
9440  IF X=0 THEN Pa(1,2)=Prob
9450  IF X<>0 THEN Pa(1,2)=Prob+Pa(1,2)
9460  NEXT X
9470  Cont(2)=0
9480  FOR X=C+1 TO Milr(I,1)-1
9490  Con(X)=X
9500   GOSUB 2770
9510  Conp(X)=Prob
9520  Cont(2)=Cont(2)+Conp(X)
9530  NEXT X
9540  Asn(2)=Mils(J)*(1+Cont(2))
9550  M=Mils(J)
9560  N=Lsize-Mils(J)
9570  Pa(2,2)=0
9580  FOR It=C+1 TO Milr(I,2)-1
9590  K=Bad-It
9600  FOR X=0 TO Milr(I,2)-1-Con(It)
9610   GOSUB 2770
9620  Pa(2,2)=Pa(2,2)+Conp(It)*Prob
9630  NEXT X
9640  NEXT It
9650  Pa(3,2)=100*(Pa(2,2)+Pa(1,2))
9660  IF Pa(3,2)>100 THEN Pa(3,2)=100
9670  Pr(2,2)=100-Pa(3,2)
9680  Cont(2)=100*Cont(2)
9690  IF (ABS(Pr(2,1)-Alpha)<=Atol) AND (ABS(Pa(3,2)-Beta)<=Btol) THEN Check=1
9700  IF (ABS(Pr(2,1)-Alpha)<=Atol) AND (ABS(Pa(3,2)-Beta)<=Btol) THEN 9800
9710  IF Check=1 THEN 9960
9720  GOTO 9950
9730  IMAGE 1X,"                                  "
9740  IMAGE 1X,"_______________[ Accept/Reject ]______________________
_______________"
```

```
9750  IMAGE 1X,"| Sample  |    Criteria     | Risk & Sampling Burden At Desired S
pecifications|"
9760  IMAGE 1X,"|  Size    | First |Second |Acceptable Quality Level| Tolerance
% Defective    |"
9770  IMAGE 1X,"| 1st| 2nd|Acc|Rej|Acc|Rej|  Pa |  Fc |Alpha|  ASN |Beta |  Pc
|  Pr |  ASN |"
9780  IMAGE 1X,"______________________________________________________________
_____________"
9790  IMAGE +,1X,"|",2(4D,"|"),4(3D,"|"),2(3(3D.1D,"|"),4D.1D,"|")
9800  IF Print<>0 THEN 9930
9810  IF Dist$="HYPER" THEN PRINT LIN(4);SPA(20);"Hypergeometric Probability Eva
luation"
9820  IF Dist$="BINOMIAL" THEN PRINT LIN(4);SPA(23);"Binomial Probability Evalua
tion"
9830  PRINT SPA(22);"Optional MIL-STD-105D Sampling Plans";LIN(1);SPA(30);"AQL="
;Aql*100;"% and LTPD=";Ltpd*100;"%"
9840  PRINT SPA(10);"Producer's Risk = ";Alpha;"±";Atol;"% and Consumer's Risk
 = ";Beta;"±";Btol;"%"
9850  IF Maxsam<1000000 THEN PRINT SPA(20);"Maximum Total Sample Constraint:";Ma
xsam
9860  IF Dist$="HYPER" THEN PRINT SPA(32);"Lot Size = ";Lsize
9870  Print=5
9880  PRINT USING 9730
9890  PRINT USING 9740
9900  PRINT USING 9750
9910  PRINT USING 9760
9920  PRINT USING 9770
9930  PRINT USING 9790;Mils(J),Mils(J),Mila(I,1),Milr(I,1),Mila(I,2),Milr(I,2),P
a(3,1),Cont(1),Pr(2,1),Asn(1),Pa(3,2),Cont(2),Pr(2,2),Asn(2)
9940  PRINT USING 9780
9950  NEXT J
9960  NEXT I
9970  IF Print=0 THEN PRINT "No plans were found which met the design specificat
ions at the specified";LIN(1);"Tolerances. Loosen the tolerances & try again!"
9980  IF Print=0 THEN 2010
9990  PRINT LIN(2);"A complete assessment of [illegible] these plans is obtainable b
y exercising";LIN(1);"Option #1 of this software segment.";LIN(4)
10000 GOTO 2010
```

APPENDIX D
SEQUENTIAL SAMPLING SOURCE CODE

APPENDIX D
SEQUENTIAL SAMPLING SOURCE CODE

```
2000  REM  Seque: Wald's Sequential Sampling Approach
2010  FOR I=1 TO 4
2020  DISP
2030  IF I=1 THEN DISP " ENTER THE ACCEPTABLE QUALITY LEVEL, STATED AS A PERCEN
T "
2040  IF I=2 THEN DISP " ENTER THE LOT TOLERANCE PERCENT DEFECTIVE, STATED AS A
 PERCENT "
2050  IF I=3 THEN DISP " ENTER THE PRODUCER'S RISK, STATED AS A PERCENT "
2060  IF I=4 THEN DISP " ENTER THE CONSUMER'S RISK, STATED AS A PERCENT "
2070  DISP
2080  BEEP
2090  IF I=1 THEN INPUT Aql
2100  IF I=2 THEN INPUT Ltpd
2110  IF I=3 THEN INPUT Alpha
2120  IF I=4 THEN INPUT Beta
2130  NEXT I
2140  Aql=Aql/100
2150  Ltpd=Ltpd/100
2160  Alpha=Alpha/100
2170  Beta=Beta/100
2180  Denom=LOG(Ltpd*(1-Aql)/(Aql*(1-Ltpd)))
2190  H1=LOG((1-Alpha)/Beta)/Denom
2200  H2=LOG((1-Beta)/Alpha)/Denom
2210  S=LOG((1-Aql)/(1-Ltpd))/Denom
2220  DISP
2230  DISP "          DO YOU WANT A COPY OF THE DERIVED LINES?    "
2240  DISP
2250  BEEP
2260  INPUT Res
2270  IF Res="NO" THEN 2420
2280  PRINT LIN(4);SPA(10);"Acceptance Line: X = -(";H1;") + ";S;"(n)";LIN(1)
2290  PRINT SPA(10);"Rejection Line: X = ";H2;" + ";S;"(n)"
2300  FOR I=1 TO 100
2310  Table(I,1)=I
2320  Table(I,2)=-H1+S*I
2330  Table(I,3)=H2+S*I
2340  IF Table(I,2)<0 THEN 2380
2350  Ck=INT(Table(I,2))
2360  IF Ck=Table(I,2) THEN 2380
2370  Table(I,2)=Ck
2380  Ck=INT(Table(I,3))
2390  IF Ck=Table(I,3) THEN 2410
2400  Table(I,3)=Ck+1
2410  NEXT I
2420  DISP
2430  DISP "  DO YOU WANT A TABLE OF THE ACCEPT/REJECT NUMBERS VERSUS NUMBER SA
MPLED?  "
2440  DISP
2450  BEEP
2460  INPUT Res
2470  IF Res="NO" THEN 2850
2480  IMAGE "_",4("___________________")
2490  IMAGE "|",4("Number  |If Total |")
2500  IMAGE "|",4("Of Unit |Defective|")
2510  IMAGE "|",4("Sampled |Acpt|Rejt|")
2520  IMAGE +,"|",4(1X,5D," |",1X,3A,"|",1X,3A,"|")
2530  PRINT LIN(4);SPA(24);"Wald's Sequential Sampling Table"
2540  PRINT SPA(24);"AQL=";Aql*100;"% & LTPD=";Ltpd*100;"%"
2550  PRINT SPA(30);"Producer's Risk= ";Alpha*100;"%"
2560  PRINT SPA(30);"Consumer's Risk= ";Beta*100;"%"
2570  PRINT USING 2480
2580  PRINT USING 2490
2590  PRINT USING 2500
2600  PRINT USING 2510
2610  FOR I=1 TO 25
2620  IF Table(I,2)<0 THEN Tab$(1)=Num$(102)
2630  IF Table(I,2)=0 THEN Tab$(1)=Num$(101)
2640  IF Table(I+25,2)<0 THEN Tab$(3)=Num$(102)
2650  IF Table(I+25,2)=0 THEN Tab$(3)=Num$(101)
2660  IF Table(I+50,2)<0 THEN Tab$(5)=Num$(102)
2670  IF Table(I+50,2)=0 THEN Tab$(5)=Num$(101)
2680  IF Table(I+75,2)<0 THEN Tab$(7)=Num$(102)
2690  IF Table(I+75,2)=0 THEN Tab$(7)=Num$(101)
2700  IF Table(I,2)>0 THEN Tab$(1)=Num$(Table(I,2))
2710  IF Table(I+25,2)>0 THEN Tab$(3)=Num$(Table(I+25,2))
2720  IF Table(I+50,2)>0 THEN Tab$(5)=Num$(Table(I+50,2))
```

```
2730  IF Table(I+75,2)>0 THEN Tab$(7)=Num$(Table(I+75,2))
2740  IF (Table(I,3)>Table(I,1)) OR (Table(I,3)<=0) THEN Tab$(2)=Num$(182)
2750  IF Table(I,3)<=Table(I,1) THEN Tab$(2)=Num$(Table(I,3))
2760  IF (Table(I+25,3)>Table(I+25,1)) OR (Table(I+25,3)<=0) THEN Tab$(4)=Num$(1
82)
2770  IF Table(I+25,3)<=Table(I+25,1) THEN Tab$(4)=Num$(Table(I+25,3))
2780  IF (Table(I+50,3)>Table(I+50,1)) OR (Table(I+50,3)<=0) THEN Tab$(6)=Num$(1
82)
2790  IF Table(I+50,3)<=Table(I+50,1) THEN Tab$(6)=Num$(Table(I+50,3))
2800  IF (Table(I+75,3)>Table(I+75,1)) OR (Table(I+75,3)<=0) THEN Tab$(8)=Num$(1
82)
2810  IF Table(I+75,3)<=Table(I+75,1) THEN Tab$(8)=Num$(Table(I+75,3))
2820  PRINT USING 2520;Table(I,1);Tab$(1),Tab$(2),Table(I+25,1),Tab$(3),Tab$(4),
Table(I+50,1),Tab$(5),Tab$(6),Table(I+75,1),Tab$(7),Tab$(8)
2830  PRINT USING 2480
2840  NEXT I
2850  F3s=(1-Beta)/Alpha
2860  F4s=Beta/(1-Alpha)
2870  Nopt=0
2880  Theta=-2
2890  F1s=(1-Ltpd)/(1-Aql)
2900  F2s=Ltpd/Aql
2910  Pps=(1-F1s^Theta)/(F2s^Theta-F1s^Theta)
2920  IF (Pps>0) AND (Pps<1) THEN 2960
2930  Theta=Theta+.04
2940  IF Theta=0 THEN 2930
2950  GOTO 2910
2960  Nopt=Nopt+1
2970  Pd(Nopt)=Pps
2980  Pa(1,Nopt)=(F3s^Theta-1)/(F3s^Theta-F4s^Theta)
2990  Asn(Nopt)=Pa(1,Nopt)*LOG(F4s)+(1-Pa(1,Nopt))*LOG(F3s)
3000  Asn(Nopt)=Asn(Nopt)/(Pps*LOG(F2s)+(1-Pps)*LOG(F1s))
3010  BEEP
3020  IF Nopt=100 THEN 3040
3030  GOTO 2930
3040  FOR I=1 TO 99
3050  FOR J=I TO 100
3060  IF Pd(I)<=Pd(J) THEN 3160
3070  Tem=Pd(I)
3080  Pd(I)=Pd(J)
3090  Pd(J)=Tem
3100  Tem=Pa(1,I)
3110  Pa(1,I)=Pa(1,J)
3120  Pa(1,J)=Tem
3130  Tem=Asn(I)
3140  Asn(I)=Asn(J)
3150  Asn(J)=Tem
3160  NEXT J
3170  BEEP
3180  NEXT I
3190  DISP
3200  DISP "  DO YOU WANT A TABLE OF Pa & ASN VERSUS PERCENT DEFECTIVE?   "
3210  DISP
3220  BEEP
3230  INPUT Re$
3240  IF Re$="NO" THEN 3420
3250  PRINT LIN(4)
3260  PRINT SPA(30);"Sequential Sampling"
3270  PRINT " `     AQL=";Aql*100;"%, Producer's Risk=";Alpha*100;"%, LTPD=";Ltpd
*100;"% & Consumer's Risk=";Beta*100;"%"
3280  PRINT "  Probability of Acceptance and Average Sample Size Versus Percent
Defective"
3290  IMAGE 7X," ",2("______________________________")
3300  IMAGE 7X,"|",2("          |Probability|Average|")
3310  IMAGE 7X,"|",2(" Percent  |    of     |Sample |")
3320  IMAGE 7X,"|",2("Defective |Acceptance |Number |")
3330  PRINT USING 3290
3340  PRINT USING 3300
3350  PRINT USING 3310
3360  PRINT USING 3320
3370  IMAGE +,7X,"|",2(6D.2D,"|",6D.2D,"% |",4D.2D,"|")
3380  FOR I=1 TO 50
3390  PRINT USING 3370;Pd(I)*100,Pa(1,I)*100,Asn(I),Pd(I+50)*100,Pa(1,I+50)*100,
Asn(I+50)
3400  PRINT USING 3290
3410  NEXT I
```

```
3420  DISP
3430  DISP "       DO YOU WANT A PLOT OF THE OC CURVE?   "
3440  DISP
3450  BEEP
3460  INPUT Res$
3470  IF Res$="NO" THEN 3660
3480  PLOTTER IS "9872A"
3490  PLOTTER 7,5 IS ON
3500  LOCATE 10,100,10,100
3510  SCALE 0,INT(Pd(100)*100)+1,0,104
3520  CSIZE 2
3530  IF Pd(100)*100<=20 THEN Inx=1
3540  IF (Pd(100)*100>20) AND (Pd(100)*100<=40) THEN Inx=2
3550  IF (Pd(100)*100>40) AND (Pd(100)*100<=80) THEN Inx=4
3560  LAXES Inx,5,0,0,-1,1
3570  MOVE Inx/2,101
3580  LABEL "Pa(%)"
3590  MOVE 5*Inx,-4
3600  LABEL "PERCENT DEFECTIVE"
3610  MOVE 0,100
3620  PEN 2
3630  FOR I=1 TO 100
3640  DRAW Pd(I)*100,Pa(1,I)*100
3650  NEXT I
3660  DISP
3670  DISP "     DO YOU WANT A PLOT OF THE AVERAGE SAMPLE SIZE TO A DECISION?
 "
3680  DISP
3690  BEEP
3700  INPUT Res$
3710  IF Res$="NO" THEN RETURN
3720  PLOTTER IS "9872A"
3730  PLOTTER 7,5 IS ON
3740  LOCATE 10,100,10,100
3750  IF Pd(100)*100<=20 THEN Inx=1
3760  IF (Pd(100)*100>20) AND (Pd(100)*100<=40) THEN Inx=2
3770  Big=-99999
3780  FOR I=1 TO 100
3790  IF Asn(I)>Big THEN Big=Asn(I)
3800  NEXT I
3810  Maxy=INT(Big)
3820  Maxy=10*INT(Maxy/10)+13
3830  SCALE 0,INT(Pd(100)*100)+1,0,Maxy
3840  CSIZE 2
3850  IF Maxy<=20 THEN Iny=1
3860  IF (Maxy>20) AND (Maxy<=40) THEN Iny=2
3870  IF (Maxy>40) AND (Maxy<=80) THEN Iny=4
3880  LAXES Inx,Iny,0,0,-1,1
3890  MOVE Inxx/2,Maxy-3
3900  LABEL "ASN"
3910  MOVE 5*Inx,-.9*Iny
3920  LABEL "PERCENT DEFECTIVE"
3930  MOVE Pd(1)*100,Asn(1)
3940  PEN 2
3950  FOR I=2 TO 100
3960  DRAW Pd(I)*100,Asn(I)
3970  NEXT I
3980  RETURN
```

APPENDIX E
MULTIPLE SAMPLING SOURCE CODE

APPENDIX E
MULTIPLE SAMPLING SOURCE CODE

```
2000  REM   *****  Multiple Sampling Plan Design  *****
2010  DISP "
"
2020  DISP "                    Multiple Sampling Design Options
"
2030  DISP "   Option Description                                  Select Code
"
2040  DISP "  >Barnard-Enters-Hamaker's Poisson Approximation
"
2050  DISP "   of Sample Size for Producer's Risk of Five
"
2060  DISP "   Percent & Consumer's Risk of Ten Percent.
"
2070  DISP "   Achieved Risks are Calculated Via the Binomial......1
"
2080  DISP "  >MIL-STD-105D Alternate Plans For Specified
"
2090  DISP "   AQL, Producer's Risk, LTPD, and Consumer's
"
2100  DISP "   Risk. Achieved risks are Calculated Via the
"
2110  DISP "   Binomial..........................................2
"
2120  DISP "
"
2130  DISP
2140  DISP "        ENTER THE SELECT CODE OF THE DESIRED OPTION."
2150  DISP
2160  BEEP
2170  INPUT Sc
2180  IF Sc<>1 THEN 4230
2190  GOSUB 2210
2200  GOTO 2360
2210  DISP
2220  DISP "   ENTER THE ACCEPTABLE QUALITY LEVEL, STATED AS A PERCENT.  "
2230  DISP
2240  BEEP
2250  INPUT Aql
2260  Aql=Aql/100
2270  DISP
2280  DISP "   ENTER THE LOT TOLERANCE PERCENT DEFECTIVE, STATED AS A PERCENT!
"
2290  DISP
2300  BEEP
2310  INPUT Ltpd
2320  Ltpd=Ltpd/100
2330  Ratio=Ltpd/Aql
2340  Row=1
2350  RETURN
2360  Diff=ABS(Ratio-Ccmt(1,2))
2370  FOR I=2 TO 20
2380  Ck=ABS(Ratio-Ccmt(I,2))
2390  IF Ck>Diff THEN 2450
2400  Row=I
2410  Tier=7
2420  IF (Row=4) OR (Row=6) OR (Row=9) OR (Row=13) THEN Tier=8
2430  IF Row=5 THEN Tier=9
2440  Diff=Ck
2450  BEEP
2460  NEXT I
2470  FOR J=1 TO 9
2480  Multi(J,2)=Ccmt(Row,J+2)
2490  Multi(J,13)=Ccmt(Row,J+11)
2500  NEXT J
2510  Ss1=INT(Ccmt(Row,21)/Aql)
2520  Ss2=INT(Ccmt(Row,23)/Ltpd)
2530  IF Ss1>Ss2 THEN Low=Ss2
2540  IF Ss1<=Ss2 THEN Low=Ss1
2550  IF Ss1>Ss2 THEN High=Ss1+1
2560  IF Ss1<=Ss2 THEN High=Ss2+1
2570  Low=INT(Low)-1
2580  IF Low<1 THEN Low=1
2590  High=INT(High)+2
2600  Plans=0
2610  DISP Low,High
2620  FOR Sample=Low TO High
2630  FOR J=1 TO Tier
```

```
2640  Multi(J,1)=Sample*J
2650  NEXT J
2660  BEEP
2670  P=Aql
2680  GOSUB 3510
2690  Cal=1-Pac
2700  Expa=En
2710  P=Ltpd
2720  GOSUB 3510
2730  Cbe=Pac
2740  Expb=En
2750   Plans=Plans+1
2760   PRINT LIN(4);SPA(16);"Optional Sampling Plan #";Plans
2770  PRINT SPA(10);"Which Approximate: Producer's Risk = 5% & Consumer's Risk =
 10 %"
2780  PRINT "The Binomial Distribution Point Estimate of Producer's Risk is ";Ca
l*100;"%,"
2790  PRINT SPA(12);"and the Point Estimate of Consumer's Risk is ";Cbe*100;"%,"
2800  IMAGE "____________________________________________________________
"
2810  IMAGE "| Total  |Cumulative |
|Cumulative|"
2820  IMAGE "| Number |Acceptance |        Cumulative Continuance Numbers
|Rejection |"
2830  IMAGE "|Of Units|  Number    |
|  Number  |"
2840  IMAGE "|Sampled |   ( A )    |_____________( C )_____________________
|___( R )__|"
2850  PRINT LIN(4);SPA(26);"Multiple Plan Specification"
2860  PRINT USING 2800
2870  PRINT USING 2810
2880  PRINT USING 2820
2890  PRINT USING 2830
2900  PRINT USING 2840
2910  FOR I=1 TO 9
2920  IF Multi(I,13)=100 THEN Tier=I-1
2930  IF Multi(I,13)=100 THEN 2970
2940  NEXT I
2950  Tier=9
2960  BEEP
2970  FOR I=1 TO Tier
2980  IF Multi(I,2)<0 THEN Start=0
2990  IF Multi(I,2)>=0 THEN Start=Multi(I,2)+1
3000  FOR J=1 TO 12
3010  Con(J)=Start+(J-1)
3020  IF Con(J)=Multi(I,13) THEN Pass=J-1
3030  IF Con(J)=Multi(I,13) THEN 3080
3040  NEXT J
3050  DISP
3060  DISP "Sorry! The program is setup to handle only 11 continuation numbers!
"
3070  GOTO 2950
3080  IF Multi(I,2)<0 THEN Tabs(1)=Num$(182)
3090  IF Multi(I,2)=0 THEN Tabs(1)=Num$(181)
3100  IF Multi(I,2)>0 THEN Tabs(1)=Num$(Multi(I,2))
3110  IF Multi(I,2)+1=Multi(I,13) THEN Ncont=0
3120  IF Multi(I,2)+1=Multi(I,13) THEN 3170
3130  FOR J=1 TO Pass
3140  IF Con(J)=0 THEN Tabs(J+1)=Num$(181)
3150  IF Con(J)<>0 THEN Tabs(J+1)=Num$(Con(J))
3160  NEXT J
3170  FOR J=Pass+1 TO 11
3180  Tabs(J+1)="XXX"
3190  NEXT J
3200  IMAGE +,"|",1X,6D,1X,"|",4X,3A,4X,"|X|",11(3A,"|"),1X,8D,1X,"|"
3210  PRINT USING 3200;Multi(I,1),Tabs(1),Tabs(2),Tabs(3),Tabs(4),Tabs(5),Tabs(6
),Tabs(7),Tabs(8),Tabs(9),Tabs(10),Tabs(11),Tabs(12),Multi(I,13)
3220  PRINT USING 2800
3230  NEXT I
3240  PRINT LIN(2);SPA(20);"A complete risk assessment is obtainable by "
3250  PRINT SPA(20);"exercising Option 5 of the Main Menu."
3260  NEXT Sample
3270  IF Plans<>0 THEN RETURN
3280  IF Plans=0 THEN PRINT " No plans were found which satisfied the design tol
erances you specified!"
3290  IF Plans=0 THEN PRINT " If you wish, you can widen the design tolerances o
n Producer's and      "
```

```
3300  IF Plans=0 THEN PRINT " Consumer's Risk and re-execute this option."
3310  IF Plans=0 THEN PRINT "          IF YOU WANT TO DO THIS, ENTER YES."
3320  IF Plans=0 THEN PRINT "                 OTHERWISE, ENTER NO."
3330  DISP
3340  BEEP
3350  INPUT Res
3360  IF Res="NO" THEN RETURN
3370  GOTO 2190
3380  REM BINOMIAL SUBROUTINE
3390  IF (S-X<0) OR (X<0) THEN Prob=0
3400  IF (S-X<0) OR (X<0) THEN RETURN
3410  IF (S-X=0) OR (X=0) THEN Prob=P^X*(1-P)^(S-X)
3420  IF (S-X=0) OR (X=0) THEN RETURN
3430  Prob=1
3440  FOR Is=1 TO X
3450  Prob=Prob*P
3460  NEXT Is
3470  FOR Is=1 TO S-X
3480  Prob=Prob*((X+Is)/Is)*(1-P)
3490  NEXT Is
3500  RETURN
3510  REM PA & EN DRILL
3520  S=Multi(1,1)
3530  Start=1
3540  Pen=0
3550  Pac=0
3560 En=Multi(1,1)
3570  FOR X=0 TO Multi(1,13)-1
3580  GOSUB 3380
3590  Con(X+1)=X
3600  Conp(X+1)=Prob
3610  NEXT X
3620  IF Multi(1,2)>=0 THEN 3670
3630  FOR X=0 TO Multi(1,13)-1
3640  Pen=Pen+Conp(X+1)
3650  NEXT X
3660  GOTO 3750
3670  FOR X=0 TO Multi(1,13)-1
3680  IF Con(X+1)<=Multi(1,2) THEN Pac=Pac+Conp(X+1)
3690  IF Con(X+1)>Multi(1,2) THEN Start=X+1
3700  IF Con(X+1)>Multi(1,2) THEN 3720
3710  NEXT X
3720  FOR X=Start TO Multi(1,13)
3730  Pen=Pen+Conp(X)
3740   NEXT X
3750  En=En+Pen*(Multi(2,1)-Multi(1,1))
3760  Pacer=1
3770  FOR It=Start TO Multi(1,13)
3780  Table(Pacer,1)=Con(It)
3790  Table(Pacer,2)=Conp(It)
3800  Pacer=Pacer+1
3810  NEXT It
3820  Pacer=Pacer-1
3830  FOR I=2 TO Tier
3840  Pen=0
3850  IF Multi(I-1,2)<0 THEN Start=0
3860  IF Multi(I-1,2)>=0 THEN Start=Multi(I-1,2)+1
3870  FOR It=Start TO Multi(I,13)-1
3880  Con(It+1)=It
3890  Conp(It+1)=0
3900  NEXT It
3910  FOR It=1 TO Pacer
3920  X=0
3930  GOSUB 3380
3940  Def=Table(It,1)+X
3950  Prdef=Table(It,2)*Prob
3960  FOR Is=Start TO Multi(I,13)-1
3970  IF Def=Con(Is+1) THEN Conp(Is+1)=Conp(Is+1)+Prdef
3980  IF Def=Con(Is+1) THEN 4030
3990  NEXT Is
4000  IF Def=Multi(I,13)-1 THEN 4030
4010  X=X+1
4020  GOTO 3930
4030  NEXT It
4040  IF Multi(I,2)<0 THEN 4100
4050  FOR It=Start TO Multi(I,13)-1
```

```
4060  IF Con(It+1)<=Multi(I,2) THEN Pac=Pac+Conp(It+1)
4070  IF Con(It+1)<=Multi(I,2) THEN Start=Start+1
4080  NEXT It
4090  IF Multi(I,2)+1=Multi(I,13) THEN 4210
4100  FOR It=Start TO Multi(I,13)-1
4110  Pen=Pen+Conp(It+1)
4120  NEXT It
4130  En=En+Pen*(Multi(I+1,1)-Multi(I,1))
4140  Pacer=1
4150  FOR It=Start TO Multi(I,13)-1
4160  Table(Pacer,1)=Con(It+1)
4170  Table(Pacer,2)=Conp(It+1)
4180  Pacer=Pacer+1
4190  NEXT It
4200  Pacer=Pacer-1
4210  NEXT I
4220  RETURN
4230  GOSUB 2210
4240  DISP
4250  Tier=7
4260  Ccrit=1
4270  DISP "ENTER THE PRODUCER'S RISK,  STATED AS A PERCENT! "
4280  DISP
4290  BEEP
4300  INPUT Alpha
4310  Alpha=Alpha/100
4320  DISP
4330  DISP "ENTER THE CONSUMER'S RISK,  STATED AS A PERCENT! "
4340  DISP
4350  BEEP
4360  INPUT Beta
4370  Beta=Beta/100
4380  FOR Plan=1 TO 15
4390  Plans=0
4400  FOR Jt=1 TO 7
4410  Multi(Jt,2)=Msplar(Plan,Jt,1)
4420  Multi(Jt,13)=Msplar(Plan,Jt,2)
4430  NEXT Jt
4440  BEEP
4450  FOR Sample=1 TO 21
4460  FOR Pass=1 TO 7
4470  Multi(Pass,1)=Pass*Msplan(Sample)
4480  NEXT Pass
4490  P=Aql
4500  GOSUB 3510
4510  Cal=1-Pac
4520  BEEP
4530  Enal=En
4540  P=Ltpd
4550  GOSUB 3510
4560  Cbe=Pac
4570  Crit=((Cal-Alpha)^2+(Cbe-Beta)^2)^.5
4580  IF (Crit>Ccrit) AND (Plans>0) THEN 5070
4590  IF Crit>Ccrit THEN 5020
4600  Ccrit=Crit
4610   PRINT LIN(4);SPA(6);"The sampling plan specified below is the closest exa
mined thusfar"
4620   Plans=Plans+1
4630  PRINT "Which Approximates: Producer's Risk =";Alpha*100;"% & Consumer's Ri
sk =";Beta*100;"%";LIN(1)

4640  PRINT "The Binomial Distribution Point Estimate of Producer's Risk is ";Ca
l*100;"%,"
4650  PRINT SPA(12);"and the Point Estimate of Consumer's Risk is ";Cbe*100;"%,"
;LIN(2)
4660  PRINT LIN(4);SPA(26);"Multiple Plan Specification"
4670  PRINT USING 2000
4680  PRINT USING 2010
4690  PRINT USING 2020
4700  PRINT USING 2030
4710  PRINT USING 2040
4720  FOR I=1 TO Tier
4730  IF Multi(I,2)<0 THEN Start=0
4740  IF Multi(I,2)>=0 THEN Start=Multi(I,2)+1
4750  FOR J=1 TO 12
4760  Con(J)=Start+(J-1)
4770  IF Con(J)=Multi(I,13) THEN Pass=J-1
```

```
4780  IF Con(J)=Multi(I,13) THEN 4830
4790  NEXT J
4800  DISP
4810  DISP "Sorry! The program is setup to handle only 11 continuation numbers!
"
4820  GOTO 4760
4830  IF Multi(I,2)<0 THEN Tabs$(1)=Num$(102)
4840  IF Multi(I,2)=0 THEN Tabs$(1)=Num$(101)
4850  IF Multi(I,2)>0 THEN Tabs$(1)=Num$(Multi(I,2))
4860  IF Multi(I,2)+1=Multi(I,13) THEN Ncont=0
4870  IF Multi(I,2)+1=Multi(I,13) THEN 4920
4880  FOR J=1 TO Pass
4890  IF Con(J)=0 THEN Tabs$(J+1)=Num$(101)
4900  IF Con(J)<>0 THEN Tabs$(J+1)=Num$(Con(J))
4910  NEXT J
4920  FOR J=Pass+1 TO 11
4930  Tabs$(J+1)="XXX"
4940  NEXT J
4950  IMAGE +,"|",1X,6D,1X,"|",4X,3A,4X,"|X|",11(3A,"|"),1X,8D,1X,"|"
4960  PRINT USING 4950;Multi(I,1),Tabs$(1),Tabs$(2),Tabs$(3),Tabs$(4),Tabs$(5),Tabs$(6
),Tabs$(7),Tabs$(8),Tabs$(9),Tabs$(10),Tabs$(11),Tabs$(12),Multi(I,13)
4970  PRINT USING 4980
4980  IMAGE "________________________________",11("____"),"____________"
4990  NEXT I
5000  PRINT LIN(2);SPA(20);"A complete risk assessment is obtainable by "
5010  PRINT SPA(20);"exercising Option 5 of the Main Menu."
5020  DISP "Plan #";Plan;" with incremental sample sizes of ";Multi(1,1)
5030  NEXT Sample
5040  DISP
5050  DISP TAB(Plan*4);"Moving to Plan";Plan
5060  DISP
5070  NEXT Plan
5080  RETURN
```

APPENDIX F
SPECIAL PURPOSE ASSESSMENT SOURCE CODE

APPENDIX F
SPECIAL PURPOSE ASSESSMENT SOURCE CODE

```
2000  REM ******      SPECIAL PLAN OC CURVE & ASN ASSESSMENT   ******
2010  IMAGE "______________________________________________________________
"
2020  IMAGE "| Total  |Cumulative |
|Cumulative|"
2030  IMAGE "| Number |Acceptance |         Cumulative Continuance Numbers
|Rejection |"
2040  IMAGE "|Of Units|  Number   |
|  Number  |"
2050  IMAGE "|Sampled |   ( A )   |                    ( C )
|   ( R )  |"
2060  PRINT LIN(4);SPA(26);"Multiple Plan Specification"
2070  PRINT USING 2010
2080  PRINT USING 2020
2090  PRINT USING 2030
2100  PRINT USING 2040
2110  PRINT USING 2050
2120  FOR I=1 TO 51
2130  Pass=0
2140 Tier=I
2150  DISP
2160  DISP "      ENTER THE NUMBER OF UNITS SAMPLED TO DECISION POINT, NUMBER
";I
2170  DISP
2180  BEEP
2190  INPUT Multi(I,1)
2200  DISP
2210  DISP "IF THE LOT CAN BE ACCEPTED AT THIS POINT,  ENTER THE ACCEPTANCE NUM
BER "
2220  DISP "IF THE LOT CAN NOT BE ACCEPTED AT THIS POINT,  ENTER A NEGATIVE N
UMBER. "
2230  DISP
2240  BEEP
2250  INPUT Multi(I,2)
2260  DISP
2270  DISP "IF THE LOT CAN BE REJECTED AT THIS POINT,  ENTER THE REJECTION NUMB
ER "
2280  DISP "IF THE LOT CAN NOT BE REJECTED AT THIS POINT,  ENTER A NEGATIVE N
UMBER. "
2290  DISP
2300  BEEP
2310  INPUT Multi(I,13)
2320  IF Multi(I,2)<0 THEN 2340
2330  IF Multi(I,2)+1=Multi(I,13) THEN 2440
2340  NEXT I
2350  DISP
2360  DISP "   SORRY! THE PROGRAM IS CURRENTLY SETUP TO HANDLE 50 TIERS, SEE
Pat Lawler"
2370  DISP
2380  BEEP
2390  FOR I=1 TO 25
2400  DISP
2410  BEEP
2420  NEXT I
2430  STOP
2440  FOR I=1 TO Tier
2450  IF Multi(I,2)<0 THEN Start=0
2460  IF Multi(I,2)>=0 THEN Start=Multi(I,2)+1
2470  FOR J=1 TO 12
2480  Con(J)=Start+(J-1)
2490  IF Con(J)=Multi(I,13) THEN Pass=J-1
2500  IF Con(J)=Multi(I,13) THEN 2550
2510  NEXT J
2520  DISP
2530  DISP "Sorry! The program is setup to handle only 11 continuation numbers!
"
2540  GOTO 2370
2550  IF Multi(I,2)<0 THEN Tab$(1)=Num$(102)
2560  IF Multi(I,2)=0 THEN Tab$(1)=Num$(101)
2570  IF Multi(I,2)>0 THEN Tab$(1)=Num$(Multi(I,2))
2580  IF Multi(I,2)+1=Multi(I,13) THEN Ncont=0
2590  IF Multi(I,2)+1=Multi(I,13) THEN 2640
2600  FOR J=1 TO Pass
2610  IF Con(J)=0 THEN Tab$(J+1)=Num$(101)
2620  IF Con(J)<>0 THEN Tab$(J+1)=Num$(Con(J))
2630  NEXT J
```

```
2640  FOR J=Pass+1 TO 11
2650  Tab$(J+1)="XXX"
2660  NEXT J
2670  IMAGE +,"|",1X,6D,1X,"|",4X,3A,4X,"|X|",11(3A,"|"),1X,8D,1X,"|"
2680  PRINT USING 2670;Multi(I,1),Tab$(1),Tab$(2),Tab$(3),Tab$(4),Tab$(5),Tab$(6
),Tab$(7),Tab$(8),Tab$(9),Tab$(10),Tab$(11),Tab$(12),Multi(I,13)
2690  PRINT USING 2010
2700  NEXT I
2710  GOTO 3220
2720  REM BINOMIAL SUBROUTINE
2730  IF (S-X<0) OR (X<0) THEN Prob=0
2740  IF (S-X<0) OR (X<0) THEN RETURN
2750  IF (S-X=0) OR (X=0) THEN Prob=P^X*(1-P)^(S-X)
2760  IF (S-X=0) OR (X=0) THEN RETURN
2770  Prob=1
2780  FOR Is=1 TO X
2790  Prob=Prob*P
2800  NEXT Is
2810  FOR Is=1 TO S-X
2820  Prob=Prob*((X+Is)/Is)*(1-P)
2830  NEXT Is
2840  RETURN
2850  REM HYPERGEOMETRIC DISTRIBUTION
2860  IF X<0 THEN Prob=0
2870  IF K<0 THEN Prob=0
2880  IF K<0 THEN RETURN
2890 IF X>K THEN Prob=0
2900 IF X>K THEN RETURN
2910 IF (K=0) AND (X=0) THEN Prob=1
2920 IF (K=0) AND (X=0) THEN RETURN
2930  IF X<0 THEN RETURN
2940  IF X>M THEN Prob=0
2950  IF X>M THEN RETURN
2960  Prob=1
2970  F(1)=K
2980  F(2)=N-K
2990  F(3)=M
3000  F(4)=N-M
3010  F(5)=X
3020  F(6)=K-X
3030  F(7)=M-X
3040  F(8)=N-K-M+X
3050  F(9)=N
3060  FOR Is=1 TO 9
3070  IF F(Is)<1 THEN F(Is)=1
3080  NEXT Is
3090  Prob=Prob*F(1)*F(2)*F(3)*F(4)/(F(5)*F(6)*F(7)*F(8)*F(9))
3100  FOR Is=1 TO 9
3110  F(Is)=F(Is)-1
3120  IF F(Is)<1 THEN F(Is)=1
3130  NEXT Is
3140  Ck=0
3150  FOR Is=1 TO 9
3160  IF F(Is)=1 THEN 3180
3170  Ck=1
3180  NEXT Is
3190  IF Ck=0 THEN RETURN
3200  GOTO 3090
3210  RETURN
3220  DISP
3230  DISP "   DO YOU WANT TO BASE YOUR RISK CALCULATIONS ON A FINITE LOT SIZE?
"
3240  DISP
3250  BEEP
3260  INPUT Re$
3270  IF Re$="YES" THEN Dist$="HYPER"
3280  IF Re$="YES" THEN DISP
3290  IF Re$="YES" THEN DISP TAB(20);"ENTER THE LOT SIZE."
3300  IF Re$="YES" THEN DISP
3310  IF Re$="YES" THEN BEEP
3320  IF Re$="YES" THEN INPUT Lsize
3330  REM ******************************************
3340  IF Re$="YES" THEN 5240
3350  REM ******************************************
3360  IF Re$="NO" THEN Dist$="BINOMIAL"
3370  P=.01
3380  REM
```

```
3390  GOSUB 3410
3400  GOTO 4120
3410  S=Multi(1,1)
3420  Start=1
3430  Pen=0
3440  Pac=0
3450 En=Multi(1,1)
3460  FOR X=0 TO Multi(1,13)-1
3470  GOSUB 2720
3480  Con(X+1)=X
3490  Conp(X+1)=Prob
3500  NEXT X
3510  IF Multi(1,2)>=0 THEN 3560
3520  FOR X=0 TO Multi(1,13)-1
3530  Pen=Pen+Conp(X+1)
3540  NEXT X
3550  GOTO 3640
3560  FOR X=0 TO Multi(1,13)-1
3570  IF Con(X+1)<=Multi(1,2) THEN Pac=Pac+Conp(X+1)
3580  IF Con(X+1)>Multi(1,2) THEN Start=X+1
3590  IF Con(X+1)>Multi(1,2) THEN 3610
3600  NEXT X
3610  FOR X=Start TO Multi(1,13)
3620  Pen=Pen+Conp(X)
3630  NEXT X
3640  En=En+Pen*(Multi(2,1)-Multi(1,1))
3650  Pacer=1
3660  FOR It=Start TO Multi(1,13)
3670  Table(Pacer,1)=Con(It)
3680  Table(Pacer,2)=Conp(It)
3690  Pacer=Pacer+1
3700  NEXT It
3710  Pacer=Pacer-1
3720  FOR I=2 TO Tier
3730  Pen=0
3740  IF Multi(I-1,2)<0 THEN Start=0
3750  IF Multi(I-1,2)>=0 THEN Start=Multi(I-1,2)+1
3760  FOR It=Start TO Multi(I,13)-1
3770  Con(It+1)=It
3780  Conp(It+1)=0
3790  NEXT It
3800  FOR It=1 TO Pacer
3810  X=0
3820  GOSUB 2720
3830  Def=Table(It,1)+X
3840  Prdef=Table(It,2)*Prob
3850  FOR Is=Start TO Multi(I,13)-1
3860  IF Def=Con(Is+1) THEN Conp(Is+1)=Conp(Is+1)+Prdef
3870  IF Def=Con(Is+1) THEN 3890
3880  NEXT Is
3890  IF Def=Multi(I,13)-1 THEN 3920
3900  X=X+1
3910  GOTO 3820
3920  NEXT It
3930  IF Multi(I,2)<0 THEN 3990
3940  FOR It=Start TO Multi(I,13)-1
3950  IF Con(It+1)<=Multi(I,2) THEN Pac=Pac+Conp(It+1)
3960  IF Con(It+1)<=Multi(I,2) THEN Start=Start+1
3970  NEXT It
3980  IF Multi(I,2)+1=Multi(I,13) THEN 4100
3990  FOR It=Start TO Multi(I,13)-1
4000  Pen=Pen+Conp(It+1)
4010  NEXT It
4020  En=En+Pen*(Multi(I+1,1)-Multi(I,1))
4030  Pacer=1
4040  FOR It=Start TO Multi(I,13)-1
4050  Table(Pacer,1)=Con(It+1)
4060  Table(Pacer,2)=Conp(It+1)
4070  Pacer=Pacer+1
4080  NEXT It
4090  Pacer=Pacer-1
4100  NEXT I
4110  RETURN
4120  IF Pac<.02 THEN 4160
4130  BEEP
4140  P=P+.01
4150  GOTO 3380
```

```
4160  DISP
4170  DISP "THE PROBABILITY OF ACCEPTANCE IS ";Pac;" FOR A PERCENT DEFECTIVE OF
";P*100
4180  DISP "   THE EXPECTED SAMPLE NUMBER IS ";En;" AT THIS PERCENT DEFECTIVE."
4190  DISP "   ENTER THE MAXIMUM VALUE OF PERCENT DEFECTIVE YOU WISH TO BE    "
4200  DISP "   SHOWN ON THE OC CURVE. THIS ENTRY MUST BE MADE AS A PERCENT!
"
4210  DISP
4220  BEEP
4230  INPUT Pmax
4240  Maxx=10*(INT(Pmax/10)+1)+1
4250  FOR If=1 TO 100
4260  Pd(If)=If*Pmax/100
4270  P=Pd(If)/100
4280  GOSUB 3410
4290  Pa(1,If)=Pac
4300  DISP Pa(1,If)
4310  Asn(If)=En
4320  NEXT If
4330  BEEP
4340  PLOTTER IS "9872A"
4350  PLOTTER 7,5 IS ON
4360  LOCATE 10,100,10,100
4370  SCALE 0,Maxx,0,103
4380  IF Maxx<=20 THEN Inx=1
4390  IF (Maxx>20) AND (Maxx<=40) THEN Inx=2
4400  IF (Maxx>40) AND (Maxx<=80) THEN Inx=4
4410  IF Maxx>80 THEN Inx=5
4420  CSIZE 2
4430  LAXES Inx,5,0,0,-1,1
4440  MOVE 4*Inx,-4.95
4450  LABEL "PERCENT DEFECTIVE"
4460  MOVE Inx/3,101
4470  LABEL "Pa(%)"
4480  MOVE 0,100
4490  PEN 2
4500  FOR I=1 TO 100
4510  DRAW Pd(I),Pa(1,I)*100
4520  NEXT I
4530  MOVE 120,200
4540  DISP
4550  DISP "       DO YOU WANT ANY OF THESE POINTS PRINTED? "
4560  DISP
4570  BEEP
4580  INPUT Res
4590  IF Res="NO" THEN 4850
4600  IMAGE 12X,"                                 ________"
4610  IMAGE 12X,"________________________________|Average|"
4620  IMAGE 12X,"|  Percent  |Acceptance  |Sample |"
4630  IMAGE 12X,"|Defective|Probability|Number |"
4640  PRINT USING 4600
4650  PRINT USING 4610
4660  PRINT USING 4620
4670  PRINT USING 4630
4680  IMAGE +,12X,"|",5D.2D,"%|",7D.2D,"%|",5D.1D"|"
4690  IMAGE 12X,"_________________________________________"
4700  DISP
4710  DISP "   ENTER THE PERCENT DEFECTIVE, STATED AS A PERCENT.  "
4720  DISP
4730  BEEP
4740  INPUT Perd
4750  P=Perd/100
4760  GOSUB 3410
4770  PRINT USING 4680;Perd,Pac*100,En
4780  PRINT USING 4690
4790  DISP
4800  DISP TAB(25);"  DO YOU WANT ANYMORE?  "
4810  DISP
4820  BEEP
4830  INPUT Res
4840  IF Res="YES" THEN 4700
4850  DISP
4860  DISP "DO YOU WANT A PLOT OF THE ASN CURVE?"
4870  DISP
```

```
4880  BEEP
4890  INPUT Res
4900  IF Res="NO" THEN RETURN
4910  PLOTTER IS "9872A"
4920  PLOTTER 7,5 IS ON
4930  Big=-9999
4940  FOR I=1 TO 100
4950  IF Asn(I)>Big THEN Big=Asn(I)
4960  NEXT I
4970  DISP
4980  DISP "                    THE LARGEST ASN IS ";Big
4990  DISP "  ENTER THE MAXIMUM ASN YOU WANT SHOWN ON THE PLOT.  "
5000  DISP
5010  BEEP
5020  INPUT Maxy
5030  LOCATE 10,100,10,100
5040  SCALE 0,Maxx,0,Maxy
5050  DISP
5060  DISP "      WHAT LABELING INTERVAL DO YOU WANT ON THE Y axis?"
5070  DISP
5080  BEEP
5090  INPUT Iny
5100  CSIZE 2
5110  LAXES Inx,Iny,0,0,-1,1
5120  MOVE Inx/3,Maxy-3
5130  LABEL "ASN"
5140  MOVE 4*Inx,-Maxy/20
5150  LABEL "PERCENT DEFECTIVE"
5160  MOVE 0,Multi(1,1)
5170  PEN 2
5180  FOR I=1 TO 100
5190  IF I=1 THEN MOVE Pd(I),Asn(I)
5200  DRAW Pd(I),Asn(I)
5210  NEXT I
5220  MOVE 500,500
5230  RETURN
5240  DISP
5250  DISP "   YOU MAY START THE SEARCH PROCEDURE BY ENTERING THE INITI   NUMBE
R OF
       "
5260  DISP "   DEFECTIVES PER LOT. A RECOMMENDATION IS MADE THAT THIS V..UE BE
10%
       "
5270  DISP "   OF THE LOT SIZE. REMEMBER, THIS ENTRY MUST BE AN INTEGER!
       "
5280  DISP
5290  BEEP
5300  INPUT K
5310  Bad=K
5320  GOSUB 5340
5330  GOTO 6040
5340  REM    HYPERGEOMETRIC EVALUATION OF SPECIAL PLAN
5350  N=Lsize
5360  Start=0
5370  M=Multi(1,1)
5380  FOR X=0 TO Multi(1,13)-1
5390  GOSUB 2850
5400  Table(X+1,1)=X
5410  Table(X+1,2)=Prob
5420  NEXT X
5430  Pac=0
5440  En=Multi(1,1)
5450  Pen=0
5460  IF Multi(1,2)<0 THEN Start=0
5470  IF Multi(1,2)>=0 THEN Start=Multi(1,2)+1
5480  Contin=Multi(1,13)-1
5490  Connum=Contin-Start+1
5500  FOR It=1 TO Connum
5510  Con(It)=Start+It-1
5520  NEXT It
5530  FOR It=1 TO Multi(1,13)
5540  IF Table(It,1)<=Multi(1,2) THEN Pac=Pac+Table(It,2)
5550  IF Table(It,1)<=Multi(1,2) THEN 5600
5560  FOR Is=1 TO Connum
5570  IF Table(It,1)=Con(Is) THEN Conp(Is)=Table(It,2)
5580  IF Table(It,1)=Con(Is) THEN 5600
5590  NEXT Is
5600  NEXT It
5610  FOR Is=1 TO Connum
```

```
5620  Pen=Pen+Conp(Is)
5630  NEXT Is
5640  En=En+Pen*(Multi(2,1)-Multi(1,1))
5650  FOR I=2 TO Tier
5660  N=Lsize-Multi(I-1,1)
5670  M=Multi(I,1)-Multi(I-1,1)
5680  Start=0
5690  FOR It=1 TO Connum
5700  K=Bad-Con(It)
5710  Lima(It)=Multi(I,13)-Con(It)-1
5720  FOR X=0 TO Lima(It)
5730  GOSUB 2050
5740  Figp(It,X+1)=Prob*Conp(It)
5750  Fig(It,X+1)=X+Con(It)
5760  NEXT X
5770  NEXT It
5780  IF Multi(I,2)>=0 THEN Start=Multi(I.2)+1
5790  Contin=Multi(I,13)-1
5800  Lim=Contin-Start+1
5810  FOR It=1 TO Lim
5820  Con(It)=Start+It-1
5830  Conp(It)=0
5840  NEXT It
5850  Pen=0
5860  FOR It=1 TO Connum
5870  FOR X=0 TO Lima(It)
5880  IF Fig(It,X+1)<=Multi(I,2) THEN Pac=Pac+Figp(It,X+1)
5890  IF Fig(It,X+1)<=Multi(I,2) THEN 5960
5900  IF Multi(I,2)+1=Multi(I,13) THEN 5960
5910  FOR Jt=1 TO Lim
5920  IF Fig(It,X+1)=Con(Jt) THEN Conp(Jt)=Conp(Jt)+Figp(It,X+1)
5930  IF Fig(It,X+1)=Con(Jt) THEN Pen=Pen+Figp(It,X+1)
5940  IF Fig(It,X+1)=Con(Jt) THEN 5960
5950  NEXT Jt
5960  REM
5970  NEXT X
5980  NEXT It
5990  Connum=Lim
6000  En=En+Pen*(Multi(I+1,1)-Multi(I,1))
6010  BEEP
6020  NEXT I
6030  RETURN
6040  IF Pac<.02 THEN 6140
6050  DISP
6060  DISP "When";Bad;" defectives are present in the lot, Pa is";Pac*100;"%."
6070  DISP "     HOLD ON I AM INCREASING THE DEFECTIVES TO SCOPE OUT THE OC CUR
VE!
  "
6080  DISP
6090  Ck=10*INT(Bad/10)
6100  Bad=Ck+10
6110  K=Bad
6120  BEEP
6130  GOTO 5310
6140  DISP
6150  DISP "   IF THE SUBMITTED LOT CONTAINS ";Bad;"DEFECTIVES, THE PROBABILITY
OF"
6160  DISP "   ACCEPTANCE IS ";Pac;". "
6170  DISP "    ENTER THE MAXIMUM NUMBER OF DEFECTIVES PER LOT, YOU WANT SHOWN
 "
6180  DISP "    ON THE OC CURVE. THIS ENTRY MUST BE AN INTEGER!
 "
6190  DISP
6200  BEEP
6210  INPUT Maxx
6220  IF Maxx<=100 THEN Incx=1
6230  IF Maxx<=100 THEN Lim=Maxx
6240  IF Maxx<=100 THEN 6320
6250  DISP
6260  DISP "WHAT INTERVAL DO YOU WANT BETWEEN SUCCESSIVE DEFECTIVES PER LOT? "
6270  DISP
6280  Lim=100
6290  Maxx=Maxx+3
6300  BEEP
6310  INPUT Incx
6320  FOR If=1 TO Lim
6330  K=If*Incx
```

```
6340  Bad=K
6350  GOSUB 5340
6360  Pa(1,If)=Pac
6370  Pd(If)=Bad
6380  DISP
6390  DISP "@ ";Bad;" defectives/lot: Pa=";Pac*100;"% & ASN=";En
6400  DISP
6410  BEEP
6420  Asn(If)=En
6430  DISP
6440  NEXT If
6450  PLOTTER IS "9872A"
6460  PLOTTER 7,5 IS ON
6470  LOCATE 10,100,10,100
6480  SCALE 0,Maxx,0,103
6490  DISP
6500  DISP "THE RECOMMENDED LABELING INTERVAL FOR DEFECTIVES/LOT IS ";INT(Maxx/1
5)
6510  DISP "          ENTER THE LABELING INTERVAL YOU WANT SHOWN        "
6520  DISP
6530  BEEP
6540  INPUT Inx
6550  CSIZE 2
6560  LAXES Inx,5,0,0,-1,1
6570  MOVE Inx/3,100
6580  LABEL "Pa(%)"
6590  MOVE 4*Inx,-4.95
6600  LABEL "DEFECTIVES PER LOT, Lot Size = ";Lsize;"Units"
6610  Lim=100
6620  IF Maxx-3<100 THEN Lim=Maxx-3
6630  MOVE 0,100
6640  FOR If=1 TO Lim
6650  DRAW Pd(If),100*Pa(1,If)
6660  DISP Pd(If),100*Pa(1,If)
6670  NEXT If
6680  MOVE 500,500
6690  FOR J=1 TO 11
6700  IF J<>6 THEN DISP
6710  IF J=6 THEN DISP "         DO YOU WANT ANY OF THESE POINTS PRINTED?"
6720  NEXT J
6730  BEEP
6740  INPUT Res
6750  IF Res="NO" THEN 7000
6760  PRINT LIN(4)
6770  PRINT USING 6800
6780  PRINT USING 6810
6790  PRINT USING 6820
6800  IMAGE 12X," ___________________________________________ "
6810  IMAGE 12X," |Defectives|Acceptance  |Sample | "
6820  IMAGE 12X," | Per Lot  |Probability|Number | "
6830  IMAGE +,12X,"|",9D," |",7D.2D,"%|",5D.1D"|"
6840  DISP
6850  DISP "            ENTER THE NUMBER OF DEFECTIVES PER LOT      "
6860  DISP
6870  BEEP
6880  INPUT K
6890  Bad=K
6900  GOSUB 5340
6910  PRINT USING 6830;Bad;Pac*100,En
6920  PRINT USING 6800
6930  DISP
6940  DISP "DO YOU WANT ANOTHER ONE?"
6950  DISP
6960  BEEP
6970  INPUT Res
6980  IF Res="YES" THEN 6840
6990  PRINT LIN(4)
7000  DISP
7010  DISP "                  DO YOU WANT AN ASN PLOT?       "
7020  DISP
7030  BEEP
7040  INPUT Res
7050  IF Res="NO" THEN RETURN
7060  Lim=100
7070  IF Maxx-3<100 THEN Lim=Maxx-3
7080  Big=-99999
7090  FOR If=1 TO Lim
```

```
7100  IF Asn(If)>Big THEN Big=Asn(If)
7110  NEXT If
7120  DISP
7130  DISP "                    THE LARGEST ASN IS ";Big
7140  DISP "  ENTER THE MAXIMUM ASN YOU WANT SHOWN ON THE PLOT.  "
7150  DISP
7160  BEEP
7170  INPUT Maxy
7180  PLOTTER IS "9872A"
7190  PLOTTER 7,5 IS ON
7200  LOCATE 10,100,10,100
7210  SCALE 0,Maxx,0,Maxy
7220  DISP
7230  DISP "      WHAT LABELING INTERVAL DO YOU WANT ON THE Y axis?"
7240  DISP
7250  BEEP
7260  INPUT Iny
7270  CSIZE 2
7280  LAXES Inx,Iny,0,0,-1,1
7290  MOVE Inx/3,Maxy*.95
7300  LABEL "ASN"
7310  MOVE 4*Inx,-Maxy/20
7320  LABEL "DEFECTIVES PER LOT, Lot Size = ";Lsize;"units"
7330  FOR If=1 TO Lim
7340  IF If=1 THEN MOVE Pd(If),Asn(If)
7350  IF (Pd(If)=0) AND (Asn(I)=0) THEN 7380
7360   DRAW Pd(If),Asn(If)
7370  NEXT If
7380  RETURN
```

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AMCPM–SM	1
SFAE–UGV	1